# THREE ESSAYS ON
# ABSORPTIVE CAPACITY BEYOND R&D

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vorgelegt von Nadia Weidner
aus Russland

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|---|---|
| Dekan: | Prof. Dr. Dieter Nautz |
| Erstgutachter: | Prof. Dr. Carsten Dreher<br>Freie Universität Berlin |
| Zweitgutachter: | FH-Prof. Dr. Oliver Som<br>Management Center Innsbruck MCI |
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## DECLARATION OF CO-AUTHORSHIP AND PUBLICATIONS

This dissertation consists of three papers. I am the sole author of two of them, and one paper was written in collaboration with two co-authors:

First paper: **Exploring absorptive capacity in non-R&D innovative firms: The interplay between individuals and organisational practices**

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Own contribution: 100%. I am the sole author.

A preliminary version of this paper titled "Exploring non-R&D-based mechanisms of absorptive capacity" was accepted for oral presentation at the ISPIM Conference, Florence, Italy, 16-19 June 2019.

Second paper: **Absorptive capacity and external search beyond R&D: Two modes of knowledge absorption in German non-R&D SMEs**

Status: rejected after the first review round at *Small Business Economics* (B-journal according to VHB-JOURQUAL3 ranking (an important and notable scientific journal in business research)).
The paper is re-submitted at *Journal of the Knowledge Economy*
(Impact factor (2020): 1.964, CiteScore (2020): 4.2, Scimago Quartile (2020): Q2).

Own contribution: 100%. I am the sole author.

A preliminary version of this paper titled "Absorptive capacity beyond R&D: Empirical insights from the German manufacturing industry" was accepted for oral presentation at the DRUID Academy Conference, Aalborg, Denmark, January 2019.

Third paper: **An integrated conceptual framework for analysing heterogeneous configurations of absorptive capacity in manufacturing firms**

Co-authorship with Oliver Som and Djerdj Horvat.

Status: under review at *Technovation* (C-journal according to VHB-JOURQUAL3 ranking (a renowned scientific journal in business research);
Impact factor (2020): 6.606, CiteScore (2020): 10.4, Scimago Quartile (2020): Q1).

Own contribution: 75%. I am the leading author and was responsible for the literature review, framework development, data collection and data analysis, as well as summarising and describing the empirical results. I wrote the corresponding sections independently, although I did receive valuable feedback from my co-authors.
Specifically, my co-authors contributed to the refinement of the developed framework and helped to verify, present and contextualise the empirical findings by contributing their extensive knowledge about the analysed companies and their organisational context.
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Two further conference papers were written and presented during the work on this dissertation:

- Weidner, N. and O. Som. "How open is 'low-tech innovation'? Empirical insights from German manufacturing industry". ISPIM Conference Proceedings. The International Society for Professional Innovation Management (ISPIM), 2015.

- Weidner, N., Som O., Horvat D. and Dreher C. "Technological absorptive capacity beyond R&D context". Accepted for oral presentation at The ISPIM Innovation Conference – Innovation, The Name of The Game, Stockholm, Sweden on 17-20 June 2018.

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## SUMMARY

In times of technological dynamics, knowledge intensification and increasing networking between business stakeholders, absorptive capacity has become one of the most prominent concepts in innovation and management research. However, despite the attention devoted to absorptive capacity in the academic community, there is still a limited understanding of how firms without institutionalised R&D departments and formal R&D expenditure can absorb and leverage external knowledge successfully. With its strong focus on R&D-intensive firms and high-tech industries as well as on R&D-related aspects, existing research has overlooked the variety in patterns of knowledge absorption and, due to its reliance on inappropriate measures, tends to underestimate absorptive capacity in non-R&D firms.

Therefore, the overall objective of this dissertation is to advance our understanding of absorptive capacity beyond the R&D-based context by providing novel empirical insights on how non-R&D-performing manufacturing firms build their AC to access and leverage external knowledge successfully in their innovation activities.

The dissertation consists of three distinct but complementary research papers. The empirical analyses in these papers are based on the qualitative data from multiple case studies of four non-R&D-performing German manufacturing firms, as well as the quantitative cross-sectional data from the German Manufacturing Survey 2015.

In the first paper, which relies on qualitative data, I explore how non-R&D firms organise their efforts to deploy absorptive capacity, and which personnel resources and organisational practices they rely on. The empirical results provide in-depth insights into the nature and specific character of the AC process in the non-R&D context, and highlight the focal role of a few key absorptive agents in the configuration of absorptive capacity. A crucial factor for success is the integration of these individuals into the process of absorptive capacity by means of aligned organisational practices.

Based on the quantitative cross-sectional data, the second paper compares non-R&D and R&D SMEs in terms of their openness to external knowledge and major external sources of innovation impulses. Further, it takes a deeper look at non-R&D SMEs and examines how the internal organisation of absorptive capacity in these firms varies depending on the type of external knowledge source targeted. The results indicate that

both non-R&D and R&D SMEs are open to external knowledge sources to a similar degree. However, non-R&D SMEs are more likely to search for innovation knowledge from suppliers and less likely to search for science-based knowledge than R&D SMEs do. Moreover, the results show that different search patterns are associated with different modes of knowledge absorption.

The third and final paper explores the heterogeneity in patterns of absorptive capacity and explains how the configuration of absorptive capacity is shaped by a firm's dominant innovation mode. To address its research objective, the paper develops an integrated conceptual framework of absorptive capacity that offers a more differentiated perspective of absorptive capacity and enables the investigation of heterogeneous configurations of absorptive capacity across different types of firms. The framework was illustrated and tested using the qualitative data from the case studies with non-R&D performing firms and was shown to be appropriate for the operationalisation of absorptive capacity configurations associated with the Doing, Using and Interacting (DUI) mode of innovation and practical, tacit knowledge. This makes this framework particularly relevant for non-R&D firms and SMEs.

This dissertation contributes to innovation management research and enriches the absorptive capacity literature in several important ways. First, by responding to the call to explore absorptive capacity beyond the R&D-based context, this dissertation provides novel empirical insights into the hitherto overlooked empirical context of non-R&D manufacturing firms. It brings more conceptual clarity and explains how non-R&D firms manage to build absorptive capacity directed towards strategically relevant knowledge. Second, this dissertation proposes a holistic conceptual framework that integrates fragmented findings from different research fields on the underlying building blocks of absorptive capacity, such as dimensions, constitutive elements and microfoundations. In doing so, it enriches our understanding of the internal configuration of a firm's absorptive capacity. Third, this dissertation explores and explains inter-firm heterogeneity in patterns of absorptive capacity, which has received little attention in the previous literature. Thus, the dissertation provides a broader understanding of absorptive capacity beyond R&D and explains how firms can build and develop their absorptive capacity in a more differentiated manner. Finally, this dissertation, and in particular the developed

framework, can serve as the cornerstone for the improved, more comprehensive operationalisation and measurement of absorptive capacity.

## ZUSAMMENFASSUNG

In Zeiten von technologischer Dynamik, Wissensintensivierung und zunehmender Vernetzung von Unternehmensakteuren ist die Absorptive Capacity zu einem der prominentesten Konzepte in der Innovations- und Managementforschung geworden. Trotz der großen akademischen Aufmerksamkeit, die der Absorptive Capacity gewidmet wird, gibt es immer noch ein begrenztes Verständnis darüber, wie Unternehmen ohne formale Forschungs- und Entwicklungsausgaben (FuE) und ohne institutionalisierte FuE-Abteilung eine ausreichende Absorptive Capacity aufbauen können. Durch die starke Fokussierung auf FuE-intensive Unternehmen und High-Tech-Industrien sowie auf FuE-bezogene Aspekte übersieht die bestehende Forschung die Vielfalt an Absorptionsmustern und neigt dazu, die Absorptive Capacity in nicht forschenden Unternehmen zu unterschätzen, indem sie ungeeignete Messindikatoren verwendet.

Daher ist das übergeordnete Ziel dieser Dissertation unser Verständnis von Absorptive Capacity über den forschungsintensiven Kontext hinaus zu erweitern, indem neuartige empirische Erkenntnisse darüber gewonnen werden, wie nicht forschende Unternehmen des Verarbeitenden Gewerbes ihre Absorptive Capacity aufbauen, um externes Wissen erfolgreich in ihren Innovationsaktivitäten nutzen zu können.

Die Dissertation besteht aus drei eigenständigen, aber komplementären Forschungsartikeln. Die empirischen Analysen in diesen Artikeln basieren auf qualitativen Daten aus Multiple-Case-Studien mit vier nicht forschenden Unternehmen des Deutschen Verarbeitenden Gewerbes sowie auf quantitativen Querschnittsdaten aus der Erhebung „Modernisierung der Produktion 2015“.

Der erste Artikel untersucht anhand der qualitativen Daten, wie nicht forschende Unternehmen ihre Absorptive Capacity aufbauen und auf welche personellen Ressourcen und organisatorischen Praktiken sie zurückgreifen. Die empirischen Ergebnisse geben Aufschluss über die Art und den spezifischen Charakter des Absorptionsprozesses im Nicht-FuE-Kontext und heben die zentrale Rolle einiger weniger hochqualifizierter Individuen bei der Konfiguration der Absorptive Capacity hervor. Ein entscheidender Erfolgsfaktor ist die Einbindung dieser Personen in den Absorptionsprozess durch geeignete Organisationspraktiken.

Basierend auf den quantitativen Querschnittsdaten vergleicht der zweite Artikel nicht forschende und forschende kleine und mittlere Unternehmen (KMU) hinsichtlich ihrer Offenheit für externes Wissen und wichtige externe Quellen der Innovationsimpulse. Darüber hinaus wird untersucht, wie die interne Organisation der Absorptive Capacity in nicht forschenden KMU in Abhängigkeit von der Art der externen Wissensquelle variiert. Die Ergebnisse zeigen, dass nicht forschende und forschende KMU in ähnlichem Maße offen für externe Wissensquellen sind. Allerdings suchen nicht forschende KMU eher nach Innovationswissen von Zulieferern und weniger nach wissenschaftsbasiertem Wissen im Vergleich zu forschender KMU. Darüber hinaus zeigen die Ergebnisse, dass unterschiedliche Suchmuster mit unterschiedlichen Modi der Absorptive Capacity in Zusammenhang stehen.

Der dritte und letzte Artikel untersucht die Heterogenität in den Absorptionsmustern und erklärt, wie die Konfiguration der Absorptive Capacity durch den dominanten Innovationsmodus des Unternehmens geprägt wird. Um das Forschungsziel zu erreichen, wird ein integriertes konzeptionelles Framework der Absorptive Capacity entwickelt, das eine differenziertere Perspektive auf die Absorptive Capacity bietet und es ermöglicht, heterogene Konfigurationen über verschiedene Unternehmenstypen hinweg zu untersuchen und empirisch zu erfassen. Das Framework wurde anhand der qualitativen Daten aus den Fallstudien mit nicht forschenden Unternehmen illustriert und getestet. Dabei zeigt sich, dass das Framework für die Operationalisierung von Absorptionskonfigurationen geeignet ist, die auf dem „Learning by Doing, Using and Interacting“ (DUI-Modus) und praktischem erfahrungsorientierten und anwendungsbasierten Wissen basieren. Dies macht dieses Framework besonders relevant für nicht forschende Firmen und KMU.

Zusammenfassend leistet diese Dissertation durch die Erfüllung des übergeordneten Forschungsziels einen wichtigen Beitrag zur Innovationsmanagementforschung. Erstens liefert diese Dissertation als Antwort auf die Forderung, Absorptive Capacity über den forschungsintensiven Kontext hinaus zu erforschen, neuartige empirische Erkenntnisse über nicht forschende Unternehmen im Verarbeitenden Gewerbe. Sie bringt mehr konzeptionelle Klarheit und erklärt, wie es nicht forschenden Unternehmen gelingt, die Absorptive Capacity aufzubauen, die sich

auf strategisch relevantes Wissen richtet. Zweitens schlägt diese Dissertation ein ganzheitliches konzeptionelles Framework vor, das fragmentierte Erkenntnisse aus verschiedenen Forschungsfeldern zu den zugrundeliegenden Bausteinen der Absorptive Capacity, wie Dimensionen, konstitutive Elemente und Microfoundations, integriert. Auf diese Weise bereichert diese Dissertation unser Verständnis darüber, wie Unternehmen Ihre Absorptive Capacity konfigurieren. Drittens untersucht und erklärt diese Dissertation die Heterogenität in den Absorptionsmustern, die in der bisherigen Literatur wenig Beachtung gefunden hat. Damit liefert die Dissertation ein breiteres, differenziertes Verständnis von Absorptive Capacity über FuE hinaus. Schließlich kann diese Dissertation, und insbesondere das entwickelte Framework, als Grundstein für eine verbesserte, umfassendere Operationalisierung und Messung von Absorptive Capacity dienen.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AC(s) | Absorptive capacity(/ies) |
| DUI | Doing, Using and Interacting |
| EU | European Union |
| IT | Information Technology |
| NACE | Nomenclature générale des activités économiques dans les Communautés Européennes |
| OECD | Organisation for Economic Co-operation and Development |
| R&D | Research and Development |
| SME(s) | Small and medium-sized firm(s) |
| STI | Science, Technology and Innovation |

# CHAPTER 1

## Introduction

### 1.1 MOTIVATION AND RESEARCH OBJECTIVE

This dissertation contributes to innovation management research by enhancing understanding about absorptive capacity in the largely overlooked context of non-R&D manufacturing firms. The concept of absorptive capacity (hereafter AC) is defined as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990). Generally, it describes how firms can generate innovations and improve performance by leveraging external knowledge. The presence of AC explains the extent to which a firm can benefit from external knowledge (Song et al., 2018). Enabling firms to reinforce their knowledge base and adapt to changes in the external environment, AC is widely acknowledged to be one of the key sources of a firm's innovativeness, competitiveness and long-term survival (Camisón and Forés, 2010; Lane et al., 2006; Lewin et al., 2011; Song et al., 2018).

It has been argued that, despite its popularity, the concept of AC is not fully developed conceptually and empirical studies do not use it to its full potential (Song et al., 2018). One of the problems hindering the conceptual progress of the concept is the strong focus on the R&D-based context, which dominates the empirical AC literature. Indeed, starting from the original works of Cohen and Levinthal (1989; 1990), research has predominantly focused on R&D-intensive firms and industries (e.g. Distel, 2017; Ebers and Maurer, 2014; Fabrizio, 2009; Jong and Freel, 2010; Lane and Lubatkin, 1998; Matusik and Heeley, 2005). The mainstream of subsequent studies also considers R&D efforts as the main predictor for a firm's ability to recognise, assimilate and exploit external knowledge (Lane et al., 2006; Murovec and Prodan, 2009). In this sense, it is suggested that firms with higher R&D investments have more innovation resources and are thus better equipped to leverage externally generated knowledge (Spithoven et al., 2011).

Further, although recent research conceptually distinguishes different organisational factors contributing to AC (cf. Hervas-Oliver et al., 2012; Jansen et al., 2005; Schmidt, 2010), the majority of studies (even those generalised to all industries and firms with any level of R&D intensity) still measure AC using R&D-based or R&D-related indicators (Jiménez-Barrionuevo et al., 2011; Lewin et al., 2011; Murovec and Prodan, 2009; Zobel, 2017). Relying on such measures is problematic for firms that do not perform formal R&D or unintentionally underreport their formal R&D expenditure and conduct R&D activities informally (Dooley et al., 2017; Moilanen et al., 2014; Muscio, 2007; Rammer et al., 2009). According to Arundel et al. (2008), on average, this type of firm accounts for more than half of the innovative companies in 27 EU member states. Findings for the manufacturing industry in Germany by Rammer et al. (2011) suggest that approximately 44% of all innovative firms do not perform in-house R&D. Consequently, by applying R&D-related measures of AC, the research tends to favour large, R&D-intensive firms (Becheikh, 2013) and is likely to systematically underestimate the AC of non-R&D-performing firms (Som et al., 2013), the majority of which are small and medium-sized enterprises (SMEs). The same argument applies to empirical studies utilising alternative, non-R&D-related measures of AC, such as non-R&D-based proxy-indicators or item scales (see Flatten et al. (2011) for a further, detailed review of AC measures). These studies also do not question whether these measures are indeed appropriate to capture AC in non-R&D firms (Lewin et al., 2011). Overall, the empirical studies professing that non-R&D performing firms have weak AC are likely to be biased by inappropriate or insufficient measures (Moilanen et al., 2014).

Consequently, in light of the above arguments, the external validity of the existing findings on firms' AC can be put into question. Existing studies do not provide deeper insights into whether the aspects of AC, which have been defined by studying R&D-intensive firms, are also relevant and adaptable for the non-R&D context (Lewin et al., 2011; Moilanen et al., 2014). Moreover, by focusing solely on the R&D context and R&D-related aspects, research runs the risk of overlooking the variety in how firms can build and strengthen their AC.

Therefore, more research is needed to balance the existing R&D bias and advance our understanding of the concept of absorptive capacity in the less studied, but highly

relevant empirical context of non-R&D-performing manufacturing firms. To date, research still has very limited understanding about AC in non-R&D manufacturing firms, which represent a relevant part of the industrial base of European economies (Dooley et al., 2017) and are of great importance for their innovation ecosystems (Arundel et al., 2008; Hirsch-Kreinsen, 2015; Hirsch-Kreinsen and Jacobson, 2008; Tunzelmann and Acha, 2005). In fact, existing studies still cannot explain how firms without formal R&D successfully manage to identify the innovation knowledge they require in various external sources and convert this into new marketable products and solutions. This applies in particular to science-based technological knowledge. While there is empirical evidence that at least some non-R&D firms leverage this type of knowledge in their innovation activities (cf. Som, 2012; Som et al., 2013), it remains unclear how these firms manage to do so in the absence of a formal R&D department and highly qualified R&D staff (cf. Escribano et al., 2009). Further, there is only limited understanding about how non-R&D firms organise and deploy their AC. What personnel and organisational resources do these firms draw on to search for and absorb external knowledge? Insights into the underlying AC process are also lacking. Does the AC process in non-R&D firms differ from that in R&D firms, and in which functional areas is the process embedded? Moreover, conceptually, it is not clear how non-R&D firms can purposefully strengthen their AC: What are the key antecedents of AC in these firms?

Accordingly, in response to the aforementioned motivating factors, the overall research question of this dissertation is formulated as follows:

> *How do non-R&D manufacturing firms build AC to access relevant external knowledge and successfully leverage it in their innovation activities?*

By contextualising the AC concept and illuminating it in non-R&D firms, this dissertation provides a more comprehensive picture of AC and addresses three important research gaps. First, it responds to the empirical call to explore AC beyond the mainstream R&D-based context (Lane et al., 2006; Lewin et al., 2011). Second, this dissertation provides more conceptual clarity about how firms configure and orchestrate their internal resources to build and deploy sufficient AC (cf. Bogers and Lhuillery, 2011; Ebers and Maurer, 2014; Martinkenaite and Breunig, 2016; Schmidt, 2010). Third, this

dissertation extends our understanding of heterogeneous AC patterns between different firms (cf. Song et al., 2018) and highlights the explanatory role of a firm's innovation strategy (cf. Jansen et al., 2005; Lane et al., 2006). The conceptual gaps are discussed in more detail in the following section.

The remainder of this chapter is structured as follows. In the next section, I elaborate on the theoretical background to this dissertation and describe the main conceptual gaps that motivated the research. Then, I introduce the empirical context and provide the definition of non-R&D firms used throughout this dissertation. After that, I present the empirical setting and research design, and describe the data used. Finally, I provide an overview of the three research papers that form the core of this dissertation.

## 1.2 THEORETICAL CONTEXT OF THE DISSERTATION

The concept of absorptive capacity was first introduced by Cohen and Levinthal (1989; 1990) and their seminal articles encompass a number of aspects fundamental to understanding AC. First, absorptive capacity is a multidimensional construct involving three underlying dimensions: (a) the capability to recognise the value of new external knowledge; (b) the capability to assimilate this knowledge; and (c) the capability to apply it to commercial ends. Depending on the conceptualisation, subsequent research distinguishes between three or four dimensions (Lane et al., 2006; Todorova and Durisin, 2007; Zahra and George, 2002). Second, AC is a multi-level construct consisting of an individual and an organisational component. On the one hand, AC depends heavily on individuals and their abilities, motivation and knowledge bases (e.g Lewin et al., 2011; Minbaeva et al., 2003; Sjodin et al., 2019). On the other hand, it is more than simply a sum of individual employees and has a distinctive organisational aspect (Cohen and Levinthal, 1990; Volberda et al., 2010). There are organisational practices and mechanisms facilitating the conversion of individual knowledge into organisational-level knowledge and enabling internal communication and knowledge transfer between and within units (e.g. Lewin et al., 2011; Song et al., 2018). Third, AC is a function of the prior related knowledge base, underscoring its cumulative and path-dependent character. The more basic knowledge and experience a firm has with a certain type of knowledge, the more perceptive it is to this type of knowledge, and the more likely it will search for

and absorb this kind of knowledge in the future (Vega-Jurado et al., 2008; Zahra and George, 2002). Fourth, the intensity of efforts is crucial for developing sufficient AC. Even though they admit that AC can be generated in a variety of ways, Cohen and Levinthal primarily focus on a firm's R&D efforts and suggest that R&D enhances a firm's ability to absorb externally generated knowledge (1989, 1990). This implies that firms with higher R&D intensity are more likely to be able to identify relevant external knowledge, absorb and leverage it to produce innovations (Hervas-Oliver et al., 2011).

The concept of AC received much academic attention after its introduction[1]. It has been argued that the concept benefitted from the rapid growth of neighbouring research areas such as organisational learning, strategic alliances, knowledge management, the resource-based view of the firm and dynamic capabilities (Lane et al., 2006; Vera et al., 2011; Volberda et al., 2010). Over the past three decades, multiple attempts have been made to refine, reconceptualise and develop the concept further to better understand the AC process and its underlying dimensions and flows, organisational antecedents, microfoundations, and effects on a firm's outcomes. Table 1.1 summarises some of the most prominent and significant contributions.

Table 1.1: State of research on the AC concept

| | |
|---|---|
| *Theoretical and conceptual studies* | |
| Contributions to the concept and new models of absorptive capacity | Lane and Lubatkin, 1998; Lewin et al., 2011; Marabelli and Newell, 2014; Martinkenaite and Breunig, 2016; Sun and Anderson, 2010; Todorova and Durisin, 2007; Zahra and George, 2002 |
| Literature reviews and integrative frameworks | Lane et al., 2006; Song et al., 2018; Van Den Bosch et al., 2003; van Wijk et al., 2011; Volberda et al., 2010; Zou et al., 2018 |
| *Empirical studies* | |
| Process dimensions of AC | Duchek, 2015a; Easterby-Smith et al., 2008; Horvat et al., 2018; Patterson and Ambrosini, 2015 |
| Organisational antecedents | Burcharth et al., 2015; Enkel and Heil, 2014; Fosfuri and Tribó, 2008; Jansen et al., 2005; Van Den Bosch et al., 1999 |
| Microfoundations of AC | Distel, 2017; Enkel et al., 2017; Lowik et al., 2017; Schweisfurth and Raasch, 2018; Sjodin et al., 2019 |
| Effects of AC on a firm's outcomes | Fabrizio, 2009; Kotabe et al., 2011; Tsai, 2001 |
| Studies aiming to improve AC measures | Camisón and Forés, 2010; Flatten et al., 2011; Jiménez-Barrionuevo et al., 2011 |

Source: The author's own research

1 Up to the end of 2020, nearly 9,000 research articles have cited the original article by Cohen and Levinthal (1990), and the phrase "absorptive capacity" appears in the title of approx. 750 research articles according to Web of Science (based on own data extraction).

### *Points of conceptual criticism*

Despite the attention paid to AC, the concept is criticised for being "reified" (Lane et al., 2006) and used as a general purpose construct (Song et al., 2018). In particular, Lane et al. (2006) argue that the findings of previous studies are rather fragmented and few researchers have examined the concept of AC critically and attempted to extend or refine its definition. Most studies have not acknowledged the theoretical assumptions of the original concept of Cohen and Levinthal and often ignored the multidimensionality of the construct (Marabelli and Newell, 2014; Murovec and Prodan, 2009), its multi-levelness (Distel, 2017; Sjodin et al., 2019) and cumulative nature (Schmidt, 2005). Some of the aspects of AC remain underexplored and there are some shortcomings in the existing literature. In the following section, I summarise the points of criticism and shortcomings that motivated the underlying research objectives of this dissertation.

*Conceptual Gap 1: Limited understanding of AC configuration along the AC process*

First, there is *little systematic knowledge of how firms build and organise their AC*, namely, which resources and mechanisms they rely on to "configure" their AC (Bogers and Lhuillery, 2011; Schmidt, 2010). Indeed, most empirical studies treat AC as an independent variable (Volberda et al., 2010) or a moderator between the external knowledge inputs and a firm's innovations and performance (e.g. Escribano et al., 2009; Morgan et al., 2018; Rothaermel and Alexandre, 2009). In doing so, they overlook the intra-organisational antecedents of AC (Ebers and Maurer, 2014; Lane et al., 2006; Volberda et al., 2010); even though Cohen and Levinthal (1990) explicitly emphasise their importance. Accordingly, Volberda et al. (2010) and Lewin et al. (2011) called for further research of the intra-organisational antecedents of AC, as these are crucial for a better understanding of how AC arises and for explaining why some firms benefit from external inflows more than others.

Studies treating AC as a dependent variable and considering its antecedents do exist (e.g. Burcharth et al., 2015; Enkel and Heil, 2014; Fosfuri and Tribó, 2008; Jansen et al., 2005; Minbaeva et al., 2003; Van Den Bosch et al., 1999), but their number is disproportionately low. These studies argue that, while the most often mentioned R&D efforts and existing knowledge stock are important (Jansen et al., 2005; Schmidt, 2010),

firms can actively manage their AC by relying on various organisational mechanisms. For instance, research refers to the following enabling factors: social integration mechanisms (Todorova and Durisin, 2007; Zahra and George, 2002), combinative capabilities, such as coordination, systems and socialization capabilities (Jansen et al., 2005; Kogut and Zander, 1992; Van Den Bosch et al., 1999; Vega-Jurado et al., 2008), human resources management practices and learning and training activities (e.g. Minbaeva et al., 2003; Murovec and Prodan, 2009; Schmidt, 2010). However, these studies provide only fragmented, isolated findings and do not offer a holistic perspective on how exactly firms configure their AC process. Therefore, there is a need to *integrate the previously fragmented research findings on antecedents.*

Additionally, there is a call to move beyond the idea that AC arises as a by-product of formal R&D (Cohen and Levinthal, 1990) and *examine the role and contribution of different functional areas* beyond the R&D department (Bogers and Lhuillery, 2011). Obviously non-R&D firms do not have a formal R&D unit and therefore appear to rely strongly on engineering and design units, as well as marketing and manufacturing departments in their innovation activities (Hervas-Oliver et al., 2012; Hirsch-Kreinsen, 2008, 2015).

Another necessary step to deepen the understanding about the AC configuration is to *shed light on the relationship between different dimensions of the AC process and their antecedents.* With only few exceptions (e.g. Horvat et al., 2018; Jansen et al., 2005), empirical studies have not examined sufficiently whether different phases of the AC process have distinct antecedents (Ebers and Maurer, 2014). Considering that the AC process and the innovation process are strongly interrelated and that the latter is characterised as being less institutionalised, informal and more intuitive in non-R&D firms (Dooley et al., 2017; Hirsch-Kreinsen, 2008), it is particularly important to gain more insights into the AC process in non-R&D firms, and understand how this is organised and managed.

Furthermore, although past research has conceptually acknowledged that AC is a multi-level construct (e.g. Lane et al., 2006; van Wijk et al., 2011) embracing an individual and organisational component, only very few studies have addressed this multi-levelness empirically and examined both individual and organisational antecedents

(cf. Distel, 2017; Yao and Chang, 2017). Studies often consider individuals as the starting point of the AC process and overlook their involvement at its later stages by shifting focus to organisational aspects (e.g. Martinkenaite and Breunig, 2016; Sun and Anderson, 2010). Hence, there is a need to *understand the individual-organisation interactions at each phase of the AC process* (Marabelli and Newell, 2014; Sjodin et al., 2019). Non-R&D firms are characterised by a below-average share of highly educated employees (e.g. Som, 2012). Since research recognises this group of employees as the core absorptive agents (Escribano et al., 2009), it is necessary to explore in depth how this resource constraint of non-R&D firms affects their multi-level AC configuration.

*Conceptual Gap 2: Lacking acknowledgement of the heterogeneity in AC patterns*

Second, existing research *hardly acknowledges the inter-firm heterogeneity in AC configurations.* There are two problems associated with the assumed homogeneity. On the one hand, the research explicitly assumes that AC is an "all-in-one" capability, allowing firms to access and benefit from any type of externally available knowledge (Murovec and Prodan, 2009). Indeed, by treating AC as a general purpose construct (Song et al., 2018), the majority of studies are not explicit about the type of knowledge being absorbed (Vega-Jurado et al., 2008; Volberda et al., 2010) or consider only technological, explicit knowledge (Lane et al., 2006; Song et al., 2018). The innovations of non-R&D firms, in contrast, tend to rely on practical, experience-based, customer-oriented and process-based knowledge and occur through the processes of learning-by-doing, -using and -interacting (DUI) (Hirsch-Kreinsen, 2008; Som, 2012). In fact, the DUI mode of learning and innovation (cf. Jensen et al., 2007) is common among non-R&D firms (Thomä and Zimmermann, 2020). Nonetheless, the research conducted to date has paid only limited attention to the absorption of tacit, market-based and process-oriented knowledge (Lane et al., 2006; Robertson et al., 2012), even though these types of knowledge are indispensable for firms' innovation activities (cf. Jensen et al., 2007). Thus, the link between AC and the type of targeted external knowledge has not been sufficiently researched. However, different types of knowledge make different demands of internal capabilities (Grimpe and Sofka, 2009; Koehler et al., 2012) and the methods of their acquisition, assimilation and exploitation may vary (Ebersberger et al., 2011).

Studies considering different types of external knowledge and distinguishing different types of AC are rather rare (e.g. Murovec and Prodan, 2009; Schmidt, 2010; Schweisfurth and Raasch, 2018; Vega-Jurado et al., 2008). Nonetheless, they provide the first indication that the internal configurations of AC are likely to depend on the nature of the targeted external knowledge. Thus, there is still a need to pay *more attention to the different types of external knowledge* and to gain a *better understanding of the influence of the type and characteristics of external knowledge on AC and its configuration* (Jansen et al., 2005; Schmidt, 2010; Song et al., 2018).

On the other hand, rooted in the limited knowledge about the internal organisation of AC, the concept is often treated as a "one-size-fits-all" capability, meaning that AC is assumed to be found in similar shapes and configurations across different firms. Such an approach implies that there should be "the recipe for success" in how firms need to combine certain internal resources so that their AC becomes a source of competitive advantage. However, firms differ in terms of their available innovation resources (Barney, 1991; Nelson, 1991) and gain competitive advantages by managing and combining these resources in different, unique ways (e.g. Teece et al., 1997). These bundles of innovation resources are the foundation for building AC. In other words, the pattern of AC is contingent upon these resources, and at least in the short run, a firm's resources determine which AC configurations are feasible and which types of knowledge can be assimilated and applied (Lane et al., 2006). If AC is considered to be the front end of a firm's innovation process, the firm's strategic orientation may be the key to better understanding the differences between firms in terms of their AC configuration. Nonetheless, *the role of a firm's strategy has been largely disregarded (Jansen et al., 2005; Lane et al., 2006).* With regard to non-R&D firms, previous research shows that these differ remarkably from R&D firms in terms of their innovation resources and innovation behaviour (Hirsch-Kreinsen, 2015; Som, 2012; Spithoven et al., 2011). Indeed, the majority of non-R&D manufacturing firms are SMEs (Arundel et al., 2008; Dooley and O'Sullivan, 2018; Dreher et al., 2018; Thomä and Zimmermann, 2020) and hence face the resource constraints that are similar to all SMEs: shortage of technological resources, financial and human capital, infrastructure and know-how (Lee et al., 2010; Rammer et al., 2009; Van de Vrande et al., 2009) . This fact shapes their innovation pattern (Som, 2012; Spithoven

et al., 2011) and is likely to shape how they configure their available innovation resources to build AC.

Table 1.2 summarises the major shortcomings in AC research that are relevant within the context of this dissertation. It is worth noting that the identified points of criticism concern AC research in general, and are not necessarily specific to non-R&D firms. However, this dissertation focuses on non-R&D firms, the majority of which are SMEs, as the opposite extreme to large R&D firms (cf. Moilanen et al., 2014), which dominate current AC research. By focusing on non-R&D firms, this dissertation makes an important contribution to bridging the identified gaps in the research, as it reveals another valuable perspective towards AC and sheds light on aspects that have been overlooked by mainstream research but are relevant for advancing AC theory.

Table 1.2: Research gaps bridged by the dissertation

| Research gaps | | Papers | | |
|---|---|---|---|---|
| | | I | II | III |
| Empirical gap | Insufficient understanding of AC in the context of non-R&D manufacturing firms | x | x | x |
| Conceptual gap 1 | Limited understanding of AC configuration along the AC process | x | x | x |
| | • need to integrate previously fragmented research findings on antecedents | | | x |
| | • need for more insights into the role and contribution of different functional areas | (x) | x | |
| | • need to shed light on the antecedents of single process dimensions of AC | | | x |
| | • need for a deeper understanding of multi-level interactions | x | | x |
| Conceptual gap 2 | Lacking acknowledgement of the heterogeneity in AC patterns | (x) | (x) | x |
| | • need for more attention to different types of external knowledge and their moderating role | | x | |
| | • need for a better understanding of the role played by a firm's strategy | (x) | | x |

Notes. x = major contribution; (x) = minor contribution

## 1.3 EMPIRICAL CONTEXT: NON-R&D MANUFACTURING FIRMS

In recent years, research has showed growing interest in firms with little or no R&D activities and highlighted innovation pathways that are not based on R&D (e.g. Arundel et al., 2008; Barge-Gil et al., 2011; Hirsch-Kreinsen and Jacobson, 2008; Lee and Walsh, 2016; Som, 2012; Tunzelmann and Acha, 2005). Nonetheless, in innovation literature, there is still no common definition for non-R&D firms (Som, 2012). Most studies define

the R&D intensity of a firm based on its sector affiliation (e.g. Dooley and O'Sullivan, 2018; Heidenreich, 2009; Santamaría et al., 2009). These studies mostly rely on the OECD classification (1994) revised by Hatzichronoglou (1997) or a modified classification by Legler and Frietsch (2007) and its more recent version by Gehrke et al. (2013). Four categories are distinguished based on the R&D intensity of the manufacturing sector and the classification of the products produced: low-tech, medium-low-tech, medium-high tech and high-tech industries. Accordingly, academics refer to firms as *low-tech* when they operate in industries with an R&D intensity less than 3% (Hatzichronoglou, 1997; OECD, 1994, 2005) or less than 2.5% (Gehrke et al., 2013; Legler and Frietsch, 2007). While such a definition can be a good starting point, it only partly reflects the individual R&D intensity of a firm, as sectors consist of a considerable mix of low-, medium- and high-technology firms (Kirner et al., 2009). Another group of studies therefore applies industry-level thresholds of R&D intensity to the firm level (e.g. Kirner et al., 2009). Firms whose individual share of R&D expenditure in total sales is less than 3% (Hatzichronoglou, 1997) or 2.5% (Gehrke et al., 2013; Legler and Frietsch, 2007) are referred to as non-R&D-intensive firms (or firms with low R&D-intensity). Table 1.3 shows the discrepancy between the sectoral classification and the firm-level R&D intensity for the German manufacturing industry.

Table 1.3: Distribution of firms with different R&D intensity within low-, medium- and high-tech manufacturing sectors on basis of NACE rev. 2 (by Gehrke et al., 2013)

| | Non-R&D-intensive firms | | R&D-intensive firms | | |
|---|---|---|---|---|---|
| *Firm's R&D expenditure as percentage of total sales* | Non-R&D-performing firms *equal to 0%* | Firms with low R&D intensity *from 0% to below 2.5%* | Firms with medium R&D intensity *from 2.5% to below 7%* | Firms with high R&D intensity *7% or higher* | Total N |
| Non-research-intensive low-tech sectors | 67% | 12% | 14% | 6% | 770 |
| Research-intensive medium-tech sectors | 45% | 10% | 23% | 22% | 348 |
| Research-intensive high-tech sectors | 24% | 8% | 17% | 51% | 96 |
| Total N | 700 | 137 | 206 | 171 | 1214 |

Source: German Manufacturing Survey 2015, Fraunhofer ISI; own calculations

Notes. The sum of percentages per row amounts to 100%.

Finally, several studies focus on the subsample of non-R&D-intensive firms, namely on *non-R&D-performing* firms only (e.g. Arundel et al., 2008; Huang et al., 2010;

Rammer et al., 2009; Som, 2012). The underlying argument is that the intensity of R&D (whether a firm spends 1% or 3% of its total sales on R&D) is not as important as whether the firm is engaged in formal R&D at all (Som and Kirner, 2015). Taking the above considerations into account, this dissertation adopts the latter approach and focuses on *non-R&D-performing firms* defined in terms of the absence of formal R&D. Regarding non-R&D-performing firms, empirical studies distinguish between (a) firms that perform no internal R&D, but may still contract external R&D (e.g. Barge-Gil et al., 2011; Rammer et al., 2009) and (b) firms that perform neither intermural nor extramural R&D activities (Som, 2012). This dissertation follows the second approach by building on the arguments that internal and external R&D expenditure often complement each other (e.g. Schmiedeberg, 2008), and firms without formal in-house R&D mainly refrain from any kind of R&D activities (Rammer et al., 2009). Therefore, in this dissertation, non-R&D-performing firms are defined as those whose total R&D expenditure amounts to 0% of their sales (see Som, 2012, who applied the same approach).

## 1.4 RESEARCH QUESTIONS AND BASIC PREMISE

This dissertation aims to advance our understanding of absorptive capacity beyond the mainstream R&D context and examine how non-R&D-performing manufacturing firms build their AC to access relevant external knowledge and use this successfully in their innovation activities.

In response to the research objective, the dissertation addresses the following overarching research questions:

- *Research Question 1:* How do non-R&D manufacturing firms organise their efforts to deploy AC, i.e. which personnel resources and organisational practices do they rely on and how they are combined?
- *Research Question 2:* Which external sources do non-R&D firms primarily rely on in their search activities, and how does the internal organisation of AC in these firms vary depending on the type of external knowledge source?
- *Research Question 3:* Do heterogeneous AC patterns exist and, if so, can they be explained by a firm's dominant innovation mode?

The cornerstone of this dissertation is the premise that firms differ in the way they build and maintain their AC, and that these differences can be traced back to the differences in a firm's innovation resources and innovation behaviour. This premise has its roots in the evolutionary innovation literature (Nelson, 1991; Nelson and Winter, 1982) in combination with the resource-based view (Barney, 1991; Peteraf, 1993; Wernerfelt, 1995). Evolutionary theory suggests that firms demonstrate considerable heterogeneity in terms of their innovation routines and innovation strategies even within similar sectors and innovation systems (Srholec and Verspagen, 2008). This heterogeneity is related to the different organisational resource bundles of firm-specific capabilities, routines, experiences, skills, and organisational forms (Barney, 1991; Teece et al., 1997; Wernerfelt, 1995). However, while controlling valuable, rare, imperfectly imitable and not substitutable resources is necessary for a firm's innovation success, it is not sufficient (Carnes et al., 2017). The emerging research stream of resource orchestration within the research-based theory argues that it is crucial how firms orchestrate their resources to create innovations, namely how managers actually structure, bundle and leverage the firm's innovation resources (Carnes et al., 2017; Sirmon et al., 2011). A number of studies provide empirical evidence for inter-firm heterogeneity in terms of firms' innovation patterns (e.g. Jong and Marsili, 2006; Leiponen and Drejer, 2007; Som, 2012), different modes of learning (e.g. Jensen et al., 2007; Parrilli et al., 2020; Thomä and Zimmermann, 2020) and the reliance on different types of internal and external knowledge (Fitjar and Rodríguez-Pose, 2013; Leiponen and Drejer, 2007; Srholec and Verspagen, 2008).

Accordingly, since R&D and non-R&D firms differ in terms of their innovation resources, dominant modes of learning and innovation patterns (cf. Kirner et al., 2009; Rammer et al., 2009; Som, 2012), this dissertation assumes that non-R&D firms and R&D also firms differ in how they configure their AC. The potential heterogeneity in AC patterns arises from which type of external knowledge is being absorbed, the internal resource bundles available and how they are configured. In this sense, the key to explaining the heterogeneity in AC patterns is a firm's innovation strategy (Jansen et al., 2005; Lane et al., 2006) since this determines: (a) which knowledge is relevant, valuable and worth being accessed and absorbed; (b) which internal resources and capabilities are

available and can be mobilised for developing AC; and (c) which efforts should be undertaken to strengthen AC if necessary (Lane et al., 2006; Martinkenaite and Breunig, 2016; West and Bogers, 2014).

## 1.5 EMPIRICAL SETTING AND RESEARCH DESIGN

The main objective of the empirical analysis in this dissertation is to explore the phenomenon of AC in non-R&D manufacturing firms and heterogeneous AC configurations, and shed light on the relationship between a firm's AC configuration and its dominant mode of innovation behaviour. In this regard, the main unit of empirical analysis are non-R&D-performing firms in the German manufacturing industry. Non-R&D-performing firms are defined as those with no formal R&D activities and no reported R&D expenditure. In contrast to non-R&D-intensive firms, which might have a few formal R&D activities, the analysis of non-R&D-performing firms enables us to isolate R&D effects and highlight non-R&D-based efforts of knowledge absorption more clearly.

### *Description of data used*

This dissertation is based on a mixed methods approach combining qualitative and quantitative data (Creswell, 2013; Jick, 1979). The first and third papers share the same data basis, namely qualitative interview data from multiple-case studies with non-R&D firms, whereas the second paper builds upon recent cross-sectional data from a large-scale survey of German manufacturing firms.

#### *Qualitative data*

In 2017, I collected qualitative data using a multiple-case study approach (Yin, 2009). Considering the nascent state of theory on AC beyond the R&D-based context, this method appeared the most appropriate to provide a rich picture of new empirical context and opportunities to explore the phenomenon in greater depth (Edmondson and McManus, 2007; Eisenhardt and Graebner, 2007; Yin, 2009). Moreover, a qualitative approach makes it possible to capture the complexity of the AC construct, its multi-

levelness and multidimensionality (cf. Duchek, 2015a; Horvat et al., 2018; Patterson and Ambrosini, 2015).

The data were obtained from four non-R&D-performing manufacturing firms in Germany, each of which represents a distinctive non-R&D-based innovation pattern (cf. Som, 2012). Compared with a single case study, conclusions from multiple cases are suggested to be more compelling, powerful and robust (Yin, 2009).

I followed the purposeful sampling strategy aimed at identifying cases, where the aspects of central importance to the research objective can be studied in depth (Patton, 1990; Seawright and Gerring, 2008; Teddlie and Yu, 2007). Accordingly, the selected cases meet two criteria (mixed purposeful sample) (Patton, 1990). First, they represent information-rich examples manifesting the phenomenon of interest, but not extremes or unusual cases (intensity sampling). In this vein, the selected non-R&D firms are innovative and possess a sufficient level of AC. Second, they are different in size, belong to different industries and have heterogeneous innovation patterns (maximum variation sampling). This allows theoretical replication, meaning that the cases are designed to cover different theoretical conditions (Yin, 2009).

I collected the primary data by means of semi-structured face-to-face interviews with the selected firms (Rowley, 2012; Yin, 2009). The interviews were centred on a problem-solving situation in the innovation process when external knowledge was required. Informed by the initial extensive literature review, I developed a semi-structured interview guide to capture the AC process and its underlying dimensions in the analysed non-R&D firms. The purpose was to obtain insights into the most important external sources of their innovation impulses and to identify the key individuals involved in the AC process and the main enabling organisational mechanisms and settings (see Appendix 2 in Chapter 2). Purposefully designed to cover such a wide range of different AC-related aspects, the interview guide allowed to collect sufficient empirical material for the first and third research papers simultaneously and thus to address two different research objectives. In the first paper, the qualitative data are used to generate explorative empirical evidence in order to better understand the internal organisation of the AC process in non-R&D firms, which resources and practices they rely on and how these are interrelated. In contrast, the third paper uses the qualitative data to illustrate the developed

framework, validate its single constitutive elements and interactions between them, as well as to identify the potential heterogeneity in the AC configurations. Thus, the first paper draws on the qualitative data from the semi-structured interviews to gain explorative empirical insights and enrich the theory. In turn, the third paper utilises these data for the purpose of testing and validating the proposed conceptual framework of AC and exploring heterogeneous AC configurations. To validate this conceptual framework, in addition to the primary data I collected in the semi-structured interviews, the third paper draws on my co-authors' insights and assessments gathered from problem-focused and narrative interviews, workshops and informal conversations during the joint research project[2] with the selected companies.

To better understand and assess AC in the non-R&D firms, deep understanding of the organisational context of these firms, including strategic orientation, innovation strategy and innovation resources, is necessary. Therefore, in both papers, the primary data were extended and complemented by additional fieldwork such as screenings of firm-specific documents, reports and materials from the same joint research project.

Considering the different research objectives of the first and third papers, I used two different approaches for data analysis and coded the empirical materials by following two separate and distinct coding frames, each representing the research focus of the corresponding papers. In the first paper, I conducted qualitative content analysis according to Mayring (2017). The category formation is based on the combination of deductive and inductive approaches (cf. Gebauer et al., 2012; Horvat et al., 2018), namely the aggregated dimensions derived deductively from the previous literature were matched with the categories inductively formed by following the "Gioia Methodology" (Gioia et al., 2013) (see Appendix 1 in Chapter 2). In the third paper, I analysed the data following the approach adapted from Jantunen et al. (2012) enabling to illustrate, test and validate

2 The co-authors and myself were part of the research team of the three-year research project "Strategic Competence Development in non-research-intensive SMEs of the manufacturing industry" (StraKosphere) funded by the German Federal Ministry of Education and Research as part of the research and development programme "Arbeiten – Lernen – Kompetenzen entwickeln. Innovationsfähigkeit in einer modernen Arbeitswelt". The project did not address the aspects of absorptive capacity, however, provided insights into the organisational context of the firms, such as their strategic orientation, innovation behaviour and innovation resources.

the developed integrated framework of AC, as well as explore inter-firm heterogeneity in AC configurations. Considering the research objective of the third paper, the interview data were coded deductively using the proposed conceptual framework as a tailor-made coding frame (see Table 4.2).

*Quantitative data*

Quantitative data from the German Manufacturing Survey 2015[3] formed another data source providing the foundation for the second paper. This regular, questionnaire-based postal survey has been conducted by the Fraunhofer Institute for Systems and Innovation Research (ISI) every two to three years since 1993. It addresses firms with at least 20 employees from all manufacturing sectors and thus represents a cross-section of the entire manufacturing industry in Germany. A randomized net sample of 15,720 firms were asked to fill in the questionnaire. Of the companies contacted, a total of 1,282 returned a usable questionnaire, which corresponds to a response rate of 8% (Jäger and Maloca, 2016). The survey provides information on modernisation trends in the manufacturing industry. The 8-page questionnaire includes a broad selection of indicators to access the implementation of innovative manufacturing technologies and innovative organisational concepts, product and product-related service innovations, performance indicators, human resources, cooperation relationships, different knowledge sources of innovation impulses, as well as general company data and a number of structural characteristics. The questionnaire is addressed to firms' general management, plant or manufacturing managers. Considering the overall objective of this dissertation, a particular advantage of this data set is that it includes a significant number of manufacturing firms that perform no formal R&D activities (e.g. Kirner et al., 2009; Som, 2012).

3 As a member of a related research team at the Fraunhofer Institute for Systems and Innovation Research (ISI), I was actively involved in the research design and questionnaire development, and responsible for the organisation and implementation of this survey round, as well as data cleansing and plausibility checks.

***Research design***

The empirical analysis in this dissertation is rooted in the literature on the AC construct and particularities of non-R&D firms and their innovation behaviour. This literature review provided the necessary foundation of this dissertation and the theoretical lens for the subsequent research design. The research design is outlined in Figure 1.1 and can be described as follows.

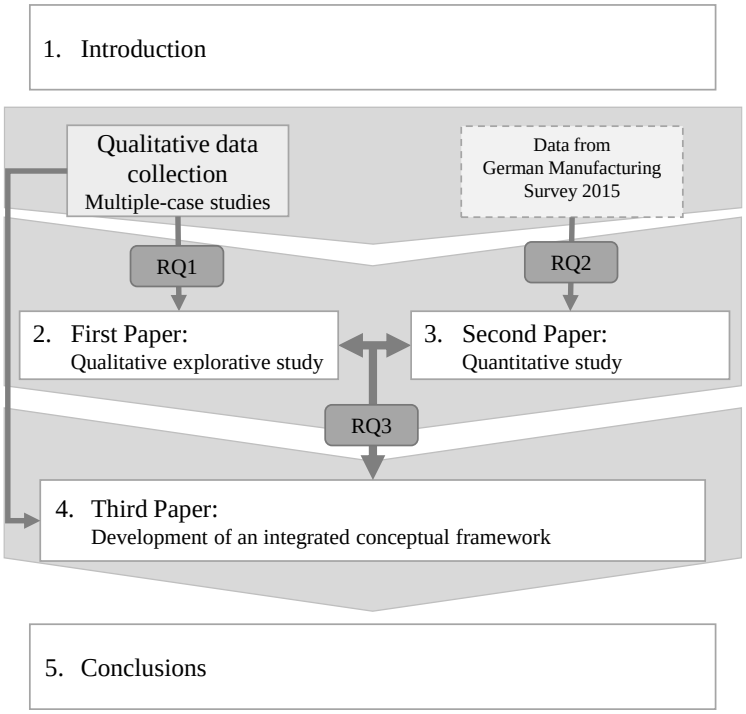


Figure 1.1: Overview of the research process
(the author's own illustration)

This dissertation consists of the three distinct but complementary research papers. The first two papers follow the concurrent triangulation approach (Creswell, 2013; Steckler et al., 1992). Even though qualitative and quantitative data were not collected at the same time, the data analysis and interpretation of results occurred in parallel and these two papers have equal weight within the dissertation. This stage of the research process underwent several iterations, where qualitative and quantitative analysis mutually enriched and cross-validated each other until the final versions of the two papers were completed. The third paper represents the logical conclusion of the research within this dissertation. Building on the empirical insights gained in the first two papers on AC in

non-R&D firms and integrating the most relevant streams of AC literature, the aim of the third paper was to develop an integrated conceptual framework providing a broader, more differentiated perspective of AC.

## 1.6 DISSERTATION STRUCTURE

The three aforementioned research questions serve as an overarching guide for the next chapters of the dissertation. In Table 1.4 and the following section, I briefly introduce each of the three papers, their theoretical focus, the gaps they address and the main empirical findings.

Conceptually, the relationship between the papers can be described using the "zooming in" and "zooming out" metaphor (Nicolini, 2009), meaning that, depending on the "theoretical lens" applied in the paper, certain aspects of the AC construct are foregrounded, while others are bracketed. In this way, each paper examines AC from a different angle.

The first paper (Chapter 2) *"Exploring absorptive capacity in non-R&D innovative firms: The interplay between individuals and organisational practices"* "zooms in" on the phenomenon of AC in non-R&D performing firms. This qualitative study is a necessary first step to explore the phenomenon in depth and better understand how manufacturing firms deploy AC directed towards technological knowledge in the absence of any R&D department and formal R&D expenditure. This paper sheds light on the individual- and organisational-level components of AC and their interplay. Consequently, this paper addresses the following research gaps. First, it responds to the call to explore AC in the less studied non-R&D-based context (Lane et al., 2006). Second, this paper provides valuable insights into how non-R&D firms configure their resources and organise the AC process. Third, it contributes to a multi-level perspective (Felin et al., 2012) and addresses the call for more attention to be paid to the individual-organisation interaction in the AC process (Martinkenaite and Breunig, 2016; Volberda et al., 2010).

Within the dissertation framework, the underlying purpose of this paper is to review the traditional assumption underlying AC and elaborate on the literature on individual-level and organisational antecedents. Further, this paper establishes the

empirical context ("empirical lens") and familiarises the reader with the specifics of a non-R&D-based context and questions the assumption about non-R&D firms displaying weak AC. Based on studies of the innovation behaviour of non-R&D firms, it describes the distinctive characteristics of these firms, their innovation behaviour and innovation resources. By highlighting the AC configurations in the analysed non-R&D firms, this paper shows that some of the findings contradict traditional assumptions in AC research.

With regard to *Research Question 1*, the paper provides empirical insights into the specific nature of the process of knowledge search and absorption in the analysed non-R&D firms. These include what the process looks like, which external knowledge sources the analysed firms target, who are the main absorptive agents and which organisational practices the firms rely on to strengthen the efforts of individuals. Moreover, it points to the necessity of aligning the organisational practices and the personnel resources involved in the AC process.

These first qualitative insights gained about the nature of AC and the specifics of its internal organisation in non-R&D firms are extended in the second paper (Chapter 3) titled *"Absorptive capacity and external search beyond R&D: Two modes of knowledge absorption in German non-R&D SMEs".* By analysing the quantitative cross-sectional data from a large-scale survey, this study "zooms out" and puts the studied phenomenon into a broader perspective. It demonstrates how prevalent knowledge search and absorption is in the entire population of non-R&D SMEs[4] in the manufacturing sector in Germany, and spotlights additional aspects of AC in the non-R&D-based context, in particular the variety in the internal organisation of AC by distinguishing two modes of knowledge absorption, each of which enables different search patterns.

By drawing attention to the empirical gap, this paper responds to the two conceptual gaps. First, it acknowledges the type and characteristics of external knowledge and their moderating role for AC configuration (Schmidt, 2010; Song et al., 2018; Volberda et al., 2010). Second, it provides a deeper understanding of the internal

4 Based on the data from the German Manufacturing Survey 2015, 93% of non-R&D-performing manufacturing firms are small and medium-sized enterprises (according to own calculation).

organisation of AC beyond the R&D department and R&D-based mechanisms (Bogers and Lhuillery, 2011).

In terms of its contribution to the dissertation, the second paper extends the literature review made in the first paper by summarising insights on the moderating role of external knowledge types and further deepening the understanding of organisational antecedents, in particular, the involvement of different functional areas. Concerning the empirical context, this paper explains why non-R&D firms are likely to organise and develop their AC in a different way than R&D-performing firms. It builds an argument that the internal organisation of AC varies depending on the type of external source targeted and suggests distinguishing the Science, Technology and Innovation (STI) and Doing, Using and Interacting (DUI) modes of AC (by drawing upon the STI and DUI modes of learning and innovation by Jensen et al., 2007).

With regard to *Research Question 2*, this study provides empirical evidence that non-R&D SMEs are open to external knowledge across different fields of innovation to a similar extent as R&D SMEs. In addition, as in R&D firms, the major sources of external knowledge in non-R&D firms are customers followed by suppliers and then universities. However, where non-R&D firms do differ significantly from their R&D counterparts is in the prevalence of the different external sources. It appears that non-R&D firms are more likely to rely on knowledge from suppliers, and less likely on science-based knowledge than R&D firms do. With regard to the internal organisation of AC associated with different external knowledge sources, the multivariate findings reveal two distinctive modes of knowledge absorption in non-R&D firms. In fact, external search oriented towards industrial knowledge source and science-driven search are embedded in different functional areas and build on the experience gained from different types of cooperation.

The third paper (Chapter 4) *"An integrated conceptual framework for analysing heterogeneous configurations of absorptive capacity in manufacturing firms"* "zooms out" even further and provides a bird's-eye view of the examined phenomenon. It proposes a conceptual framework to capture AC not only in the widely studied R&D firms, but also in non-R&D firms, and to account for the heterogeneity in AC

configurations across different types of firms. While the framework is literature-informed, its development was shaped by the insights gained in the first two studies. The findings of the first paper show that the analysed non-R&D firms do not follow the typical STI mode of knowledge absorption, but still manage to absorb technological knowledge, even research-based knowledge without formal R&D activities. Expanding on this finding, the second paper suggests distinguishing the STI and DUI modes of AC configurations associated with different external search patterns. It argues that firms target only strategically relevant external knowledge, and the configuration of their AC reflects the specific characteristics and demands of this knowledge. This idea is further developed in the third paper linking firms' AC configurations to their innovation patterns and strategic goals. Specifically, the developed framework embraces four key pillars of AC, which are transverse to the AC process. These pillars make it possible to describe the AC configuration in a more systematic way and consequently account for inter-firm heterogeneity in AC configuration.

Concerning *Research Question 3*, the findings of the third paper support the heterogeneity assumption. Empirical insights from the case studies provide anecdotal evidence for qualitative validation of the proposed framework and allow the potential heterogeneity in the AC patterns to be explored in the context of the firms' different innovation patterns. By focusing on the non-R&D firms in the empirical analysis, this paper was able to shed more light on hitherto underresearched aspects, such as the absorption of practical, applicable technological knowledge within the context of DUI-mode innovations. This makes the proposed framework particularly relevant for firms without R&D and for SMEs. Nevertheless, the framework is relevant for R&D firms as well because it views AC in a more differentiated manner and enables a holistic understanding and broader operationalisation beyond the narrow R&D focus.

In summary, this introduction established the common ground for the three independent research papers presented in the next three chapters of this dissertation. After the three papers, the concluding chapter (Chapter 5) summarises the findings that address the overall research objective and answer the research questions. Then, the major theoretical contributions of the entire dissertation are discussed, followed by its

contributions to innovation management and innovation policy. Finally, its limitations and the avenues for future research are presented.

Table 1.4: Overview of the chapters

| | Chapter 2 | Chapter 3 | Chapter 4 |
|---|---|---|---|
| Overall research question | How do non-R&D manufacturing firms organise their efforts to deploy AC, i.e. which personnel resources and organisational practices do they rely on and how they are combined? | Which external sources do non-R&D firms primarily rely on in their search activities, and how does the internal organisation of AC in these firms vary depending on the type of external knowledge source? | Do heterogeneous AC patterns exist and, if so, can they be explained by a firm's dominant innovation mode? |
| Main aspects | - organisational antecedents<br>- individual-level antecedents<br>- multi-level interaction<br>- technological knowledge<br>- non-R&D manufacturing firms | - organisational antecedents<br>- external search and potential AC<br>- heterogeneity in external knowledge sources<br>- two modes of internal organisation of AC<br>- comparison of R&D and non-R&D SMEs | - process dimensions<br>- individual-level antecedents<br>- organisational antecedents<br>- multi-level interaction<br>- technological knowledge<br>- heterogeneity in AC configurations<br>- role of a firm's innovation strategy |
| Research objectives | - to gather empirical insights into how non-R&D firms deploy their AC and<br>- to examine how individuals and organisational practices are interrelated in the process of knowledge absorption | - to examine whether there are differences between R&D and non-R&D SMEs in terms of their openness to external knowledge and the prevalence of different external search patterns<br>- to investigate the internal organisation of AC in non-R&D SMEs by distinguishing two modes of AC facilitating different search patterns | - to propose a conceptual integrated framework of firms' AC that captures the main constitutive elements of the construct throughout the entire AC process and accounts for the heterogeneity in AC patterns<br>- to explore the heterogeneity in non-R&D firms' AC configurations in the context of different strategic orientations and heterogeneous innovation behaviour |

(Table 1.4 Continued)

| | Chapter 2 | Chapter 3 | Chapter 4 |
|---|---|---|---|
| Data used | In-depth multiple case studies with 4 non-R&D-performing manufacturing firms in Germany<br>- Primary data collected by means of semi-structured face-to-face qualitative interviews<br>- Secondary data (e.g. firm-specific documents, reports and materials from the joint research project) | German Manufacturing Survey 2015<br>Sample of 1090 manufacturing SMEs, including 651 non-R&D SMEs | In-depth multiple case studies with 3 non-R&D-performing manufacturing firms in Germany<br>- Primary data collected by means of semi-structured qualitative interviews<br>- Secondary data (e.g. firm-specific documents, reports and materials from the joint research project) |
| Method of data analysis | - Qualitative content analysis according to Mayring (2017)<br>- Category formation based on the combination of deductive and inductive coding following the "Gioia Methodology" (Gioia et al., 2013). The coding frame is presented in the Appendix in Chapter 2. | - Bivariate analysis and multivariate analysis (binominal logistic regressions) | - Qualitative data analysis following the approach adapted from Jantunen et al. (2012).<br>- Deductively coding of interview data using the developed conceptual framework as a coding frame. The coding frame is presented in Table 4.2 in Chapter 4. |
| Main findings | - Non-R&D firms pursue an individual-centred approach to knowledge absorption.<br>- To integrate key individuals into a collective outcome, they deploy several matching organisational practices.<br>- The alignment between individuals and the organisational mechanisms is decisive for the success of external knowledge absorption in non-R&D firms. | - Non-R&D SMEs do not differ from R&D SMEs in terms of their openness and major external sources of innovation knowledge.<br>- Compared with their R&D-performing counterparts, non-R&D SMEs are more likely to search for supplier-based knowledge and less likely to search for science-based knowledge.<br>- In non-R&D firms, DUI and STI modes of AC can be distinguished: Different search patterns are embedded in different functional areas and build on different prior knowledge stocks, captured by experience with different types of cooperation. | - The results highlight the firm-specific character of AC patterns and thus support the heterogeneity assumption.<br>- How firms configure the AC elements reflects their dominant innovation mode and strategic goals. |

# CHAPTER 2

## Exploring absorptive capacity in non-R&D innovative firms: The interplay between individuals and organisational practices

**Abstract:** How do manufacturing firms without formal R&D manage the absorption of external technological knowledge? Despite the extensive academic attention devoted to absorptive capacity, there is still a limited understanding of the concept beyond the R&D context. It is often assumed that non-R&D firms are not well equipped to benefit from external impulses. To question this assumption, this study explores how non-R&D firms deploy their absorptive capacity, and reveals how individuals and organisational practices are interrelated in the process of knowledge absorption. Based on qualitative data from case studies with four non-R&D-performing German manufacturing firms, the results reveal that these firms pursue an individual-centred absorption of external knowledge by relying on a few key individuals from different departments. To effectively integrate individual capabilities into a collective outcome, the analysed firms deploy diverse organisational practices. Thus, the interplay between individuals and organisational mechanisms seems to enable and foster knowledge absorption in the non-R&D context.

**Keywords:** absorptive capacity; non-R&D firms; multi-level perspective; external knowledge sources; case studies

## 2.1 INTRODUCTION

Openness in innovation and reliance on external knowledge sources are widely acknowledged to be crucial for a firm's innovation success and competitiveness (Chesbrough, 2003; Dahlander and Gann, 2010; West and Bogers, 2017). To capture value from such openness and be able to benefit from external knowledge impulses, firms require absorptive capacity (hereafter AC) (Cohen and Levinthal, 1990; Zahra and George, 2002). The concept of AC is well established for large, R&D-intensive firms operating in high-tech industries and the majority of empirical findings in AC research stem from the analysis of such firms (e.g. Lane and Lubatkin, 1998; Lenox and King, 2004; Patterson and Ambrosini, 2015). In contrast, much less is known about AC in manufacturing firms without formal R&D, even though about half of all European firms innovate without performing R&D (Arundel et al., 2008).

Interest in the AC of non-R&D-performing firms is motivated by two contradictory aspects. On the one hand, reliance on external innovation sources may help non-R&D-performing firms to complement limited internal resources (e.g. Santamaría et al., 2009). On the other hand, in order to access and exploit external knowledge sources successfully, these firms need sufficient internal resources and competences. As non-R&D innovators are predominantly SMEs (Arundel et al., 2008; 2015), they are usually limited in terms of the financial resources and qualified personnel (Hirsch-Kreinsen, 2015; Lee et al., 2010; Rammer et al., 2009; Van de Vrande et al., 2009).

Previous empirical studies showed that, despite their lack of formal R&D, non-R&D firms successfully access and use technological, scientific knowledge if this knowledge is of high strategic relevance to them (e.g. Bender, 2008) and therefore do have sufficient AC. However, to date, deeper insights are still missing into how non-R&D firms manage the absorption of external knowledge and which internal resources and organisational practices enable such absorption. Hence, this study aims to explore the construct of AC beyond the R&D-based context. By applying a qualitative explorative approach, it shows how non-R&D firms deploy AC, and how individuals and organisational practices interrelate in the process of knowledge absorption.

This study contributes to AC research by responding to a call to explore AC beyond the R&D-based context (Lane et al., 2006). Given the marked differences in

structural characteristics, innovation resources and innovation behaviour between non-R&D and R&D firms (e.g. Som, 2012), it is to be expected that non-R&D firms absorb knowledge in a different way to R&D firms. Therefore, this study identifies and highlights aspects of AC that are not noticeable in the studies dominated by a R&D focus, but that are useful for advancing the theoretical development of the concept.

Furthermore, this study advocates the need for a better understanding of the multi-level nature of AC (Volberda et al., 2010). In order to unpack the concept of AC in the less studied non-R&D context, it applies a multi-level perspective (e.g. Felin et al., 2012). The results underline the importance of the interplay and fit between individual capabilities and organisational mechanisms for enabling and fostering the absorption of technological knowledge in non-R&D firms.

In addition, this study responds to the methodological critique (Flatten et al., 2011; Murovec and Prodan, 2009) and uses qualitative research methods to open up new perspectives on studying AC and to extend the ideas based largely on quantitative research.

The paper is organised as follows. The next section summarises the existing literature on AC and familiarises the reader with the non-R&D-based context by describing distinctive characteristics of non-R&D-performing firms. The third section explains the research design of the qualitative study and introduces the cases selected for analysis. This is followed by a description and a discussion of the main cross-case findings. The final section closes by summarising the contributions of the study.

## 2.2 THEORETICAL BACKGROUND

### *Existing theory on absorptive capacity*

The concept of AC was introduced by Cohen and Levinthal (1989; 1990) and defined as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (1990, p. 128). After its introduction in 1989 by Cohen and Levinthal, the concept of absorptive capacity has been enhanced in a number of reconceptualisations (e.g. Lane et al., 2006; Lewin et al., 2011; Todorova and Durisin, 2007; Van Den Bosch et al., 1999; Volberda et al., 2010; Zahra and George, 2002).

One of the latest definitions of AC was introduced by Zahra and George (2002). They extend the original concept (Cohen and Levinthal, 1989; Cohen and Levinthal, 1990) by concentrating on internal processes and defining AC as a dynamic capability embedded in a firm's routines. They were the first to split AC into potential and realised dimensions. The potential dimension reflects a firm's ability to acquire and assimilate external knowledge, whereas the realised dimension embraces a firm's ability to transform and exploit this knowledge.

Subsequent research has largely adopted the core underlying assumptions proposed in the seminal work of Cohen and Levinthal (1990). First, the research adopted the strong R&D focus and considers investments in R&D to be the main determinant of AC (Easterby-Smith et al., 2008; Lane et al., 2006; Lewin et al., 2011; Volberda et al., 2010). It is widely assumed that firms with high R&D efforts are better able to absorb external knowledge. In accordance with this assumption, the research mainly applies quantitative measures that rely on R&D expenditure or R&D personnel to operationalise and quantify AC (Lewin et al., 2011; Murovec and Prodan, 2009), even though the idea that R&D is an important predictor of AC has not been supported empirically (Flatten et al., 2011; Murovec and Prodan, 2009).

Another traditional assumption widely accepted in the literature is that AC is a function of the level of prior related knowledge. Prior knowledge includes skills, shared language, but also knowledge of the most recent technological or scientific trends and developments in a given field (Cohen and Levinthal, 1990). A firm's knowledge base is built on prior investments in the individual absorptive capacities of its employees (Lane et al., 2006; Marabelli and Newell, 2014). In other words, organisational AC is affected by the individual stocks of prior knowledge possessed by individuals (Cohen and Levinthal, 1990; Minbaeva et al., 2003; Schmidt, 2010). Therefore, reemphasising the assumption regarding prior related knowledge, research often suggests that the larger the share of highly qualified personnel, the higher the firm's AC (Schmidt, 2010; Vega-Jurado et al., 2008).

Furthermore, the construct of AC has been characterised as cumulative and path- or history-dependent (Cohen and Levinthal, 1990; Lane et al., 2006). If the firm has developed expertise in a certain area, it is more likely to search for new knowledge from

domains closely related to this area (Laursen, 2012; Vega-Jurado et al., 2008). Existing expertise and experience facilitates learning and permits the firm to better understand and value new knowledge from a related area (Fosfuri and Tribó, 2008).

*Individual component of absorptive capacity*

Previous research has also recognised that AC is a multi-level construct (Van Den Bosch et al., 2003; Volberda et al., 2010). Cohen and Levinthal (1990), followed by, e.g. Lane et al. (2001), Van Den Bosch et al. (2003) and van Wijk et al. (2011), emphasise that, although AC is defined as an organisational construct, individuals are of high importance.

Following the arguments of Cohen and Levinthal (1990), several researchers investigated individual aspects of AC, mainly focusing on employees' human capital. These included "general" aspects, such as formal education, qualification, and abilities, and "firm-specific" aspects, such as tacit knowledge, skills and experience developed at the workplace (e.g. Minbaeva et al., 2003; Schmidt, 2010; Teirlinck and Spithoven, 2013). Minbaeva et al. (2014) extended the HR perspective on AC by arguing that employees' abilities are even more valuable when coupled with high motivation and opportunities.

The core underlying assumption is that highly qualified and highly skilled employees contribute significantly to building a firm's knowledge stock. Following this line of argument, previous research considered employees with a high level of individual AC, such as R&D staff, scientists and engineers, to be the key promoters of organisational AC (e.g. Escribano et al., 2009; Veugelers, 1997). These key employees have a higher level of knowledge, are better at recognising opportunities, detecting and managing external knowledge flows, and are therefore more likely to generate new knowledge and know-how (Cohen and Levinthal, 1990; Lowik et al., 2017; Teirlinck and Spithoven, 2013). This is why firms with higher shares of such employees tend to have a higher level of AC (Grimpe and Sofka, 2009; Schmidt, 2010; Vega-Jurado et al., 2008).

In addition to human capital, several studies also emphasise the relevance of social capital for a firm's AC (Lowik et al., 2017). Their higher social capital means that highly educated and skilled employees as well as managers function as interfaces between a firm and its external environment. They have links to external experts and therefore make it

easier for a firm to access relevant external knowledge (Todorova and Durisin, 2007; Zahra and George, 2002). Besides this function, managers and key employees engage in information provision within the firm (Lenox and King, 2004). The research emphasises the important organisational roles of boundary spanners and gatekeepers (Cohen and Levinthal, 1990; Ter Wal et al., 2017; Volberda et al., 2010). These individuals scan the environment for relevant knowledge, bring it into the firm and transform it so that other employees can understand and use it to develop new products, processes and services (Lewin et al., 2011).

*Organisational component of absorptive capacity*

While individual employees are the key drivers of a firm's AC, organisational AC is not simply a sum of its individuals' ACs. It also has a distinctly organisational component (Cohen and Levinthal, 1990; Lane et al., 2006; van Wijk et al., 2011). Therefore, mechanisms that convert the knowledge acquired by individuals to organisational-level knowledge play a crucial role in AC research (Cohen and Levinthal, 1990; Lewin et al., 2011; Song et al., 2018). Previous literature has explored such enabling organisational structures and distinguished diverse organisational capabilities and practices that foster information flows and knowledge sharing across organisational units and between individual employees. For example, Kogut and Zander (1992), Van Den Bosch et al. (1999) and Jansen et al. (2005) draw attention to combinative capabilities, including coordination, systems and socialisation capabilities. Other studies investigate single practices, such as cross-functional interfaces, participation in decision-making, job rotation, formalisation practices, and quality circles (e.g. Burcharth et al., 2015; Vega-Jurado et al., 2008). Following the notion of Cohen and Levinthal (1990) regarding the importance of investments in employees' skills to enhance their individual AC, some studies underpin the high relevance of training and learning activities for a firm's AC (Minbaeva et al., 2003; Murovec and Prodan, 2009; van Wijk et al., 2011).

Recent research argues that analysing AC at the level of individuals accounts for the heterogeneity in AC at the organisational level (Distel, 2017). There are, however, only few studies that explore the relationships between different levels of AC. In particular, scholars have paid only sparse attention to the role of individual absorptive

capacities and their interplay with organisational AC (Lane et al., 2006; van Wijk et al., 2011; Volberda et al., 2010).

### *Distinctive characteristics of non-R&D firms*

Despite the extensive academic attention paid to AC and the many attempts to refine and reconceptualise the concept, it has not been explored to its full potential (Volberda et al., 2010). The majority of studies did not examine the concept critically as a rule (Lane et al., 2006) or consider whether the underlying assumptions are also relevant for contexts other than the R&D-based one.

In light of these shortcomings, the previous research findings cannot be generalised to include firms without formal R&D. Due to its excessive focus on R&D and technological, science-based knowledge, previous AC research has not paid enough attention to sources of heterogeneity in AC, such as the nature of targeted external knowledge, the type of targeted innovation outcome, as well as the available resources and capabilities necessary to deploy the AC process. In fact, a firm's strategy and innovation pattern have an impact on the nature of AC (Lane et al., 2006). Different types of innovation rely on different types of knowledge (Fitjar and Rodríguez-Pose, 2013). Accordingly, depending on its innovation objective, the firm determines which knowledge is relevant, valuable and worth acquiring and exploiting. Knowledge from different sources varies in its nature, complexity and level of applicability (Vega-Jurado et al., 2008) and hence requires a specialised form of AC (Grimpe and Sofka, 2009; Murovec and Prodan, 2009; Schmidt, 2010). To develop specialised AC, the firm relies on different internal resources and organisational mechanisms (Bogers and Lhuillery, 2011). Depending on the business and innovation strategy, firms can mobilise different internal resources and create different organisational settings to deploy their AC.

Therefore, to understand and properly capture AC in firms that do not perform formal R&D, we have to look at these potential sources of heterogeneity and find out whether their manifestations in non-R&D firms deviate from large R&D-intensive firms operating in high-tech industries – the main focus of previous AC research.

Compared with R&D firms, non-R&D firms have markedly different characteristics (see Table 2.1). First, their structural characteristics differ in terms of

industry affiliation, and firm size (Som, 2012). Non-R&D-intensive firms are predominantly SMEs (Arundel et al., 2008; 2015) and mainly present in mature, low- and medium-tech industries (Heidenreich, 2009). Their limited resources due to their absolute size shape the scope and the focus of their innovation activities (Dooley et al., 2017) and are expected to shape their approach to managing AC.

Table 2.1: Comparison of the specifics of non-R&D firms with the mainstream research on AC

| Potential sources of heterogeneity | Mainstream research on AC | Specifics of non-R&D firms |
|---|---|---|
| Industry affiliation and firm size | mainly large firms operating in high-tech industries (e.g. Cockburn and Henderson, 1998; Lane and Lubatkin, 1998; Lenox and King, 2004; Mowery et al., 1996; Patterson and Ambrosini, 2015; Tsai, 2001) | mainly SMEs in mature, low- and medium-tech industries (e.g. Arundel et al., 2008; Heidenreich, 2009; Hirsch-Kreinsen, 2015) |
| Targeted innovation outcome | dominant focus on product innovations; other fields of innovations are neglected (Bogers and Lhuillery, 2011; Murovec and Prodan, 2009) | prevalence of process, organisational and marketing innovations (Arundel et al., 2008; Kirner et al., 2009; Som, 2012) |
| Relevant knowledge | technological, research- or science-based knowledge from universities and research organisations (Song et al., 2018; Volberda et al., 2010) | high relevance of practical, experience-based, tacit knowledge from suppliers and customers (Tunzelmann and Acha, 2005) |
| Main human resources | highly educated and skilled employees (R&D staff, scientists and engineers) as the main promoters of the AC process (Cohen and Levinthal, 1990; Minbaeva et al., 2014; Schmidt, 2010) | low share of highly educated personnel (Som 2012); innovations mainly rely on engineers and technicians, marketing employees and design staff, and production employees (Hirsch-Kreinsen, 2015) |
| Organisational embeddedness | excessive focus on R&D efforts and the crucial role of the R&D department (Easterby-Smith et al., 2008; Grimpe and Sofka, 2009; Lane et al., 2006; Lewin et al., 2011; Volberda et al., 2010) | no R&D department; innovation resources from different departments, such as manufacturing, marketing and design (Arundel et al., 2008; Hervas-Oliver et al., 2011) |

Source: The author's own research

Second, non-R&D and R&D firms show different innovation behaviour and pursue different innovation patterns (Hirsch-Kreinsen and Jacobson, 2008), which are argued to be widely independent of structural aspects, and of sectoral affiliation in particular (Som, 2012). Whereas the majority of research on AC concentrates on product innovations only (Bogers and Lhuillery, 2011), non-R&D firms do not always target product innovations. To survive strong cost competition in low- and medium-tech industries, these firms are more likely to rely on process, organisational and marketing innovations (Arundel et al., 2008; Heidenreich, 2009; Kirner et al., 2009; Som, 2012). In fact, firms with lower levels of R&D frequently concentrate their innovation efforts on

production processes. Therefore, these firms are often referred to in the literature as "process specialists" (Hirsch-Kreinsen, 2015). Further, non-R&D-intensive firms also follow a "customer-oriented" or "market-driven" innovation strategy (Grimpe and Sofka, 2009; Santamaría et al., 2009) that aims at a rapid response to customer needs and takes advantages of market niches (Hirsch-Kreinsen, 2015). These fields of innovation, which do not usually originate from R&D activities, have been largely neglected by the previous research on AC (Bogers and Lhuillery, 2011; Murovec and Prodan, 2009).

Third, the knowledge base relevant for their innovation activities differs between non-R&D and R&D firms. Research on AC implicitly assumes technological, research- or science-based knowledge as the type of knowledge that firms possess internally or search for externally (Song et al., 2018). In contrast, the knowledge relevant to non-R&D firms is regarded mainly as "practical knowledge" (Hirsch-Kreinsen and Jacobson, 2008; Kastelli et al., 2018; Tunzelmann and Acha, 2005). In fact, low-tech innovations are usually not the outcome of the latest scientific or technological knowledge (Bender, 2008). These are more likely to rely on practical, experience-based, tacit knowledge (Heidenreich, 2009; Tunzelmann and Acha, 2005). Within the firm, new ideas are often generated in the context of ongoing operations (Hervas-Oliver et al., 2011; Hirsch-Kreinsen, 2008).

To extend their internal resources and reduce the uncertainty associated with innovation activities, non-R&D firms engage in innovation networks, and cooperate with and source external knowledge from different partners (Rammer et al., 2009; Santamaría et al., 2009). Since the relevant knowledge of non-R&D firms is usually distributed across a range of technologies, actors and industries (Kastelli et al., 2018), the knowledge base of these firms can be characterised as distributed (Caloghirou et al., 2014; Hirsch-Kreinsen, 2008). Given the scarcity of R&D resources, the remarkable ability of non-R&D firms to bridge the gap between different knowledge domains can be considered the main source of new ideas (Caloghirou et al., 2014) and represents one of the key factors for their innovation and economic success (Bender, 2008). To search for new technological impulses, non-R&D firms rely primarily on customers or suppliers (Heidenreich, 2009). Industrial partners provide them with valuable practical information about innovative manufacturing techniques as well as insights into new technological

developments and their applications. The knowledge provided by suppliers and customers is usually less complex, less abstract, more applicable (Vega-Jurado et al., 2008) and is easier to access directly and integrate internally than knowledge from research organisations. On the other hand, some non-R&D firms also access and utilise complex, science-based knowledge if this knowledge is of high strategic relevance to them (Bender, 2008; Som et al., 2013). Empirical findings show that the share of non-R&D firms relying on research-based knowledge for innovations is not high (16% compared to 34% among R&D firms), but not negligible (Weidner and Som, 2015). Regarding the existing research on AC, the literature often overlooks the fact that different kinds of knowledge and different knowledge sources are associated with different types of specialised AC (Schmidt, 2010).

Finally, non-R&D and R&D firms differ in terms of the available innovation resources and capabilities. While the research on AC emphasises the crucial role of R&D departments and high shares of highly qualified, even scientific personnel (e.g. Escribano et al., 2009), non-R&D firms lack a formal R&D department and are characterised by a below-average share of highly qualified employees. Instead, non-R&D firms utilise innovative resources from different departments within the firm, such as manufacturing, marketing and design (Arundel et al., 2008; Hervas-Oliver et al., 2011) and draw on the competences of the staff responsible for the ongoing operations: engineers and technicians, marketing employees and design staff as well as production workers (Arundel et al., 2008; Hirsch-Kreinsen, 2015). The main ideas for innovations can be ascribed to a few key individuals in the organisation: managers and key knowledge workers (e.g. Hirsch-Kreinsen, 2008; Jones, 2006). Considering that many of the drivers of innovation performance are also drivers of a firm's AC (Escribano et al., 2009), it is likely that, in the absence of an R&D department and dedicated R&D personnel, non-R&D firms devolve knowledge absorption to other departments (Bender, 2008; Som et al., 2013).

To summarise, since non-R&D firms differ from R&D firms in terms of their innovation behaviour, innovation objective, relevant knowledge base and internal resources and competences, it seems obvious that there must also be differences in how non-R&D firms identify, assimilate and exploit relevant external knowledge.

## 2.3 RESEARCH DESIGN, SAMPLING AND METHOD

### *Case study design and approach*

This paper empirically explores the phenomenon of AC in innovative non-R&D-performing manufacturing firms by applying an exploratory, qualitative research approach (Straus and Corbin, 1998). This research design was chosen as the appropriate strategy because the main goal of the paper is to reinvestigate the mature construct of AC in the new context (Edmondson and McManus, 2007). In the context of non-R&D firms, the concept has rather a nascent nature: there is only a small number of studies that explore AC in less technologically intensive environments beyond the R&D context (e.g. Bogers and Lhuillery, 2011; Grimpe and Sofka, 2009; Moilanen et al., 2014; Spithoven et al., 2011). Additionally, this qualitative approach makes it possible to address the multi-level aspects of the AC construct and provides insights into the interplay between individual and organisational components of AC. The case study approach and design is summarised in Figure 2.1.

For the empirical setting, non-R&D-performing firms are defined as firms with no internal R&D activities in terms of R&D expenditure. An analysis of non-R&D-performing firms (in contrast to non-R&D-intensive firms) makes it possible to isolate R&D effects and highlight non-R&D-based mechanisms more clearly (e.g. Arundel et al., 2008; Rammer et al., 2009).

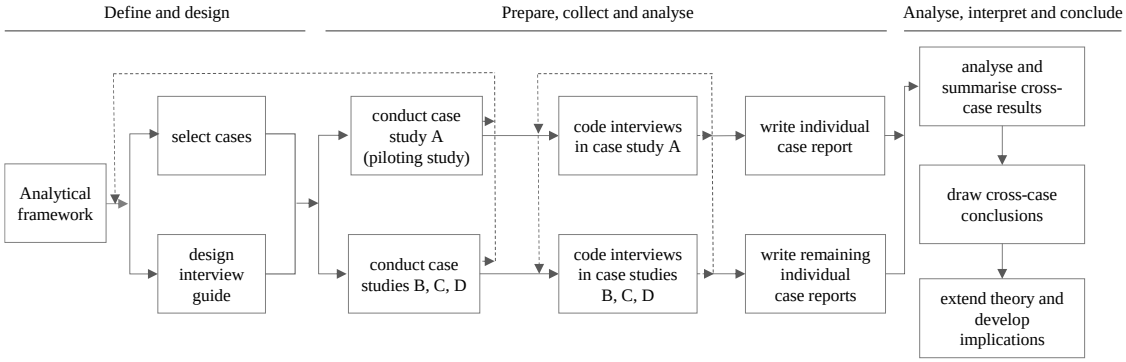


Figure 2.1: Case study approach
(Adopted from Yin (2006))

Four cases were identified using theoretical sampling that target non-R&D-performing innovative firms in the German manufacturing industry. As the study aims at

analytical generalisation (Yin, 2006), firms in the sample have different sizes and belong to different industries (see Table 2.2).

Table 2.2: Description of companies

| Case | Sector | Number of employees | Position in the value chain | Product complexity |
|---|---|---|---|---|
| A | Metal products | ca. 200 | Supplier of parts/components | low to medium |
| | Company A operates in the aluminium processing industry and is a supplier to the automotive industry. It produces technical extruded parts and assemblies. The core competences of this company lie in cold forming by impact extrusion combined with use of innovative processing techniques. The company develops its solutions according to customer needs and specifications. | | | |
| B | Metal/plastic products | ca. 100 | Supplier of parts/components | low to medium |
| | Company B operates in the metal and plastics processing industry and produces technical parts for the mechanical engineering, automotive and aircraft industries. Its expertise is both machining metal using CNC machinery, and machining plastics by injection moulding. | | | |
| C | Manufacture of furniture | ca. 450 | Producer of finished goods | low to medium |
| | Company C is an innovative manufacturer of furniture. Its main product is swivel chairs for a range of customer groups – end users, business customers, etc. Production comprises many individual steps; the internal logistic is strongly automated, whereas the pure manufacturing of the chairs consists of rather simple activities (packing, weighing, gluing). | | | |
| D | Electrical equipment | ca. 50 | Supplier of parts/components | rather low |
| | Company D is a manufacturer of customer-tailored electric heating components. Its most important sales markets are the plastics industry and the general mechanical engineering sector. | | | |

To control for extraneous variation (Eisenhardt, 1989), all four firms have the necessary capability to absorb new technological knowledge. On the one hand, one of the main competitive advantages of the analysed firms (and this is common for non-R&D firms in general) is their ability to adapt and optimise their manufacturing processes by adopting and effectively using new manufacturing technologies. In this context, technological AC plays a crucial role for a firm's success and competitiveness. On the other hand, all four firms have close contacts to universities and regularly participate in research projects, both technical and non-technical, with universities and other research institutes. This fact suggests that these firms possess the necessary competences and capacities to absorb research-based, scientific information (cf. Murovec and Prodan, 2009). In previous research, this was considered an indication for a high level of AC (Cassiman and Veugelers, 2000).

In 2017, the primary data were collected in semi-structured qualitative interviews (Miles and Gilbert, 2005). In order to keep the scope of the investigation feasible, the interviews were structured around situations in which a firm needed external technological knowledge for a process innovation. AC was operationalised by focusing

on organisational problem-solving activities embracing the search for relevant external knowledge, its absorption and deployment (adopted from Katila and Ahuja, 2002 and Laursen and Salter, 2006). Table 2.3 provides an overview of the number of interviews and interview partners. The interviews were recorded, transcribed and analysed. To assure the construct validity (Eriksson and Kovalainen, 2015; Yin, 2006), additional sources of evidence were used for the analysis (data triangulation), such as internal documents, organigrams, presentations, informal conversations; as well as written materials and reports from previous research projects in which these firms were involved.

Table 2.3: Interviews conducted

| Case | Number of interviews | Length of interviews | Interviewed persons |
|---|---|---|---|
| A | 4 interviews | 5 hrs in total | Two top managers,<br>Head of Technical Sales/Engineering,<br>Head of Construction/Toolmaking |
| B | 1 interview | 1 hr | Top manager |
| C | 1 interview | 1 hr | Top manager |
| D | 2 interviews | 2.5 hrs in total | Two top managers |

***Qualitative content analysis***

Qualitative content analysis according to Mayring (2017) was used to analyse the collected data. The category formation embraces both deductive and inductive aspects (cf. Gebauer et al., 2012; Horvat et al., 2018). All data were coded using MAXQDA software. In the first step, aggregated dimensions were derived deductively from the literature. The interviews were analysed along the following two dimensions: personnel resources involved in AC (individual component of AC), and organisational mechanisms (organisational component of AC). These dimensions provided the orientation for an initial analysis of interviews and the identification of inductive categories. In the next step, following the "Gioia Methodology" (Gioia et al., 2013), 1$^{st}$ order concepts and 2$^{nd}$ order themes were inductively formed. The analysis of the data began with the open coding of the interview materials on the basis of in vivo phrases used by the interviewees. Each interview was read several times and the coding categories were re-adjusted and consolidated. Thus, after several iterative reviews, the 1$^{st}$ order codes were formed. Concurrently with the development of the 1$^{st}$ order codes, these codes were grouped into 2$^{nd}$ order themes. Iterating between coding categories, interview materials and literature,

the 2nd order themes were revised and refined. In the final step, the 2nd order themes were matched with the deductively derived aggregated dimensions. The coding frame is presented in Figure 2.2. in the Appendix.

## 2.4 FINDINGS AND DISCUSSION

### *Specifics of absorptive capacity in non-R&D firms*

The first and main question guiding the empirical analysis was how non-R&D firms, which lack formal R&D activities and R&D personnel, manage the absorption of external technological knowledge, and whether their AC differs from that of R&D-performing firms.

When searching for external knowledge, the four firms generally aim at incremental innovation and conduct a "local search" (Laursen, 2012) targeting knowledge domains closely related to the firms' current knowledge base. Focusing on "local" knowledge with low complexity but a high degree of applicability shapes how these firms deploy their AC and is reflected in the specifics of the AC process.

It is worth emphasising that the AC of non-R&D firms is not necessarily low level. On the one hand, the absorption of complex knowledge and distant search are also possible in a non-R&D context. Besides the fact that all four non-R&D firms rely on impulses from academic and research partners, the interviews reveal that Company C and Company D follow an explorative strategy that targets more distant knowledge domains. On the other hand, even if the inputs from a single external source are relatively straightforward in most cases, complexity arises from the "distributed knowledge base". To find a solution to a technical problem, especially to a complex and nontrivial one, the analysed firms draw on impulses from a number of partners and diverse knowledge sources. The interviewed firms stated a wide variety of different sources: scientific and professional online and printed publications, visits to trade fairs and professional events, active participation in networks and working groups, contacts to suppliers, customers, industry representatives, competitors, as well as to universities, research institutes, R&D offices and laboratories. To handle the complexity and find a novel solution, non-R&D firms definitely require sufficient AC. In the absence of formalised R&D processes, these

firms have to make greater efforts to combine different impulses and apply more sophisticated organisational practices.

Further, the analysis of the interviews reveals that the AC process in the studied non-R&D firms is rather informal and more intuitive. This reflects the literature suggesting that innovations in non-R&D firms occur in a less strategical, more informal ad hoc way than is the case in R&D firms (e.g. Hirsch-Kreinsen, 2008). Nonetheless, this does not mean that they lack strategic planning (cf. Dooley et al., 2017), simply that their AC has a more emergent nature.

Linking these findings to the previous research on different types of AC and different types of search strategies, we can assume that the non-R&D firms commonly follow a "problemistic search" strategy (Laursen, 2012) that focuses on addressing a specific problem. Such a problem-driven, purposive approach to knowledge absorption is likely to be more affordable for non-R&D firms, considering their limited internal resources. Since this approach is not necessarily restricted to non-R&D firms only, this finding may open the discussion in AC research on whether striving for an optimum level of AC instead of a maximum level may be more reasonable, considering the costs of building AC (cf. Volberda et al., 2010).

In addition, the analysed firms not only actively search for new knowledge, but also passively receive relevant impulses from long-standing partners. Thanks to close, mutual relationships, suppliers and customers are familiar with the specific needs and technical scope of their non-R&D partners and inform them of relevant technologies and new trends. As the interviews show, this is particularly beneficial if the external knowledge is too theoretical and complex, and the knowledge base of the non-R&D firm is not sufficient for it to identify potentially valuable information on its own. Linking this finding to previous research, the firm's suppliers and customers operate as "knowledge intelligence units" (Spithoven et al., 2011), monitoring and identifying relevant trends from academia and informing the non-R&D firm about them. In this setting, high-tech suppliers (or customers) possess AC oriented towards scientific, research-based knowledge, and after processing this knowledge, provide low-tech partners with its more applicable form. As can be seen in Case B, universities can also undertake part of the knowledge absorption process. Spithoven et al. (2011) describe this function as acting as

"knowledge agencies" that transform knowledge and technology on behalf of the non-R&D firms. It is worth emphasising that the analysed firms have to integrate the knowledge received on their own, in order to exploit it for their innovations. This would be not possible without key individuals and well-functioning organisational practices.

***Reliance on a few key individuals***

In the absence of a formal R&D department and R&D staff, different groups of employees with different qualification levels contribute to the process of knowledge absorption in the analysed firms. To absorb technological knowledge relevant for process innovations, the interviewed firms rely on managers and a handful of key employees, mainly engineers. This underpins the arguments that having the right mix of people leads to a greater AC (Duchek, 2015b; Lowik et al., 2017; Marabelli and Newell, 2014).

In all four firms, the promoters of the AC process seem to have the power and opportunities not only to bring new ideas into the organisation, but also to promote and expedite their implementation (cf. Jones, 2006; Minbaeva et al., 2014). In accordance with the arguments on the importance of individual social capital for AC (Lowik et al., 2017), the key knowledge workers in the analysed firms have dense personal networks of contacts with diverse external partners and experience with sourcing knowledge in the form of previous participation in cooperation, joint projects, co-developments, or joint tests.

Moreover, employees with lower qualifications, such as master craftsmen or skilled production workers can be important promoters of AC during the integration and transformation phases. This underlines the argument that the skills required vary between innovation fields and technicians appear more relevant for incremental innovations, especially for process innovations (cf. Freel, 2005). Furthermore, in Companies A and B, management has recognised the importance of involving production workers in decision-making right from the phase of searching for the relevant technologies in order to ensure future acceptance of any new solution. This finding extends the existing AC research that only indicates the high relevance of highly educated employees. Lower qualified employees have been largely neglected, even though they can be of high relevance for the absorption of tacit knowledge.

Table 2.4: Individual component of AC

| Themes | Illustrative quotes (translated from German) |
|---|---|
| Promoters of AC | "…this has strategic importance and depends on the management or technical sales." (Case A, interview 1).<br>"In principle, there are three central responsible persons. One is the production manager, the other is our purchasing manager and myself [top manager]." (Case C, interview 1)<br>"An important instrument is a certain group of employees who deal with such projects. This is a group of eight people in total. And this group has the beautiful name Team Technology [...] because of their activity, since they have a lot to do with technology in their normal areas of responsibility." (Case D, interview 1) |
| Human capital | "And because of our size and niche orientation, we don't change [our technologies] so often [...] because we only need very, very small partial innovations in order to be marketable again and again. That is what we do with the people we have. And I have to admit that we very often have to try things out. Think, plan, try, correct, if necessary." (Case A, Interview 1)<br>"There is a lot of demand for innovation from ourselves. Here, the people are very strong. So we have 4-5 really good people."(Case C, interview 1)<br>"Qualification is always good. If you also respect the fact that there are different people who can be organised in different ways and that teams are heterogeneous, then you can do a lot right with it." (Case D, interview 1) |
| Social capital | "From my first employment, I [Head of Construction/Toolmaking] have actually quite good contacts to different universities. [...] [It works] through personal contacts, because you are in this area for a while, you meet one or the other or you make a phone call [...] And that is how you come up with one or the other idea." (Case A, Interview 4)<br>"[We took the contact to the university] in our own hands, because we have employees who studied there and they then used their contacts." (Case B, interview 1)<br>"The purchasing manager, because he travels all over the world and gets an unbelievable amount of input. [...] Also the production manager. [...] And as I said, bigger trends are coming from my side [top manager], from the whole research environment, because I am involved in the very different research projects." (Case C, interview 1) |
| Motivation and opportunities | "Then it is decisive how nutritious the soil is: the more qualified and motivated the employees are, the easier it is for something new to emerge. Even if you bring in something completely new. [...] That means a lot of process innovations come from us, from the abilities of our people." (Company A, interview 1)<br>"We want to follow what is new on the market, what is new on the technology front, from which I may not be able to profit today but tomorrow. So when the time comes, you study the relevant literature." (Case A, interview 3)<br>"[The motivation] was also high. Because a new machine, a modern control system means further development for the employees." (Case B, interview 1)<br>"Shift workers are often former workers, so they blossom incredibly and soak up new knowledge, and that of course inspires them to acquire knowledge by themselves. What they now research on the Internet, I found really exciting." (Case C, interview 1) |

### *Integrating key employees by means of organisational practices*

Considering non-R&D firms lack a designated R&D unit and have only a small number of highly educated and skilled employees, their main challenge is how to use the resources of these key employees effectively and efficiently and to integrate the processes and tasks related to knowledge absorption into their daily operations. To tackle this challenge, the analysed firms deploy several organisational practices that enhance human capital, or the

firm's knowledge base, as well as strengthen the integration of individuals into the collective outcome. The greater the variety and complexity of the specific targeted knowledge, the greater the efforts firms have to undertake and the more important the role these practices play.

*Investment in qualifications to enhance individual absorptive capacity*

The more limited the personnel resources of non-R&D firms are, the more important the qualifications and competences of each single employee become. Firms can enhance their AC by investing in education, training programmes and qualification measures (cf. Cohen and Levinthal, 1990). Companies A and B mainly rely on necessary qualification measures with a task-specific focus for production employees. Companies C and D, on the other hand, provide their employees with opportunities to participate in diverse external training courses that have both a task-specific and an interdisciplinary focus in order to equip different groups of employees with the skills needed to meet new requirements and new market and technology challenges. The high importance of investments in human capital for a firm's AC is in line with the previous literature on low-tech industries. For example, Santamaría et al. (2009) suggest that training is especially important for these firms, because their employees need hybrid qualifications and knowledge from different domains due to the distributed knowledge base (Santamaría et al., 2009).

*Purposeful positioning of boundary spanners*

The interviews with the companies demonstrate that non-R&D firms can overcome the challenge of limited personnel resources by positioning key players purposefully within an organisation. The position of key employees with relevant experience and expertise determines what kind of knowledge flows into an organisation and how it is then transferred and used within it.

To recognise and assimilate relevant technological knowledge, the analysed firms rely on external boundary spanners and gatekeepers, especially managers and those with an academic degree. These promoters participate in external and internal networks and link external knowledge with the needs and requirements of the firm. In other words, they

know where to search for valuable knowledge externally and how it could be relevant internally. From the interviews, it appears to be advantageous if the persons in this position have a good strategic perspective and a broad overview of organisational processes. This is in accordance with previous research (cf. Minbaeva et al., 2014).

Internal boundary spanners are relevant for knowledge transformation and exploitation. They function as an interface within an organisation and forge links between departments that have different expertise and "speak different languages". For example, in Company A, such an interface is provided by master craftsmen who connect engineers with production workers. The existence of such an organisational role becomes more important with increasing problem complexity.

*Cultivation of mechanisms facilitating intra-organisational information exchange*

In the absence of a designated R&D unit, the process of absorbing technological knowledge in the analysed non-R&D firms is widely distributed across different departments: engineering and construction, production, procurement, marketing, sales and customer service. In general, even if the absorption process appears to be less structured and more intuitive, such broad anchoring can be advantageous for the firms considering that they rely on impulses from diverse external knowledge sources and can channel these impulses through different interfaces.

In order to disseminate knowledge effectively between different departments, firms rely on organisational mechanisms that stimulate intra-organisational information and knowledge sharing. It appears that the previously studied social integration mechanisms (e.g. Burcharth et al., 2015; Vega-Jurado et al., 2008; Zahra and George, 2002) are positively associated with AC in the analysed non-R&D firms as well. The four firms show a strong reliance on cross-functional teams, regular formal and informal communications between groups of employees involved in knowledge absorption, the participation of key employees in decision-making with regard to the acquisition and integration of new technologies, as well as documentation of the main findings obtained during the process of knowledge absorption.

*Alignment of organisational settings*

In order to integrate the tasks and activities related to knowledge absorption into daily operations, the analysed firms have created (purposefully or intuitively) settings and structures favourable to developing AC. The data suggest it is beneficial if a firm officially assigns the formal responsibilities related to monitoring the external environment, learning and staying up-to-date to a particular (groups of) employees and dedicates working hours to these tasks, rather than considering them an activity for any spare time. Furthermore, Companies C and D demonstrate that an organisational culture is crucial that empowers employees, encourages experimentation, tolerates failures, and facilitates information flows.

An interesting distinction was found between the firms in terms of how to integrate key individuals into the AC process. The organisational AC of Company D can be seen as a pool, to which different employees contribute their individual ACs. In practice, this means that several employees from different functional areas are encouraged to search for external ideas to solve a concrete problem and then to channel them in a cross-functional interface. All relevant ideas are discussed during regular meetings. After the most promising solution has been collectively selected, a project team is put together to pursue this idea. By including different perspectives and professional backgrounds, Company D ensures access to different knowledge domains and is able to conduct not only narrow, problem-centred searches, but also distant searches for external knowledge. In Companies A and B, the organisational AC is more of a chain, which connects individual ACs sequentially. Key knowledge workers from engineering or construction are mostly responsible for knowledge acquisition and assimilation (and partly transformation), but its exploitation takes place in production. Accordingly, AC is organised as a sequence of tasks. Each employee in this sequence has their own specialisation, fulfils their task in the AC process and then passes it on to the next employee. The employees interact with each other only to hand over their results or if problems occur that cannot be solved without involving others.

Table 2.5: Organisational component of AC

| Themes | Illustrative quotes (translated from German) |
|---|---|
| Investments in qualifications | "It only works if you work permanently on the skills, on the qualifications of the people involved. Not as a guided process, but that everyone is permanently aware of the developments and trends within their area of responsibility [...] That means the process developer for the tools must be in contact with the tool manufacturers, new cutting materials, new geometries, new production methods. The engineer must be in contact with the machine manufacturers. This is a permanent cycle that must not be interrupted." (Company A, interview 2)<br>"We put an incredible amount of money into it [in building IT competences]. That is the big topic, [...] you cannot do anything else than attend the trainings every 4 weeks." (Case C, interview 1)<br>"Today we have a meeting structure in the area of shift leaders and the next management level. So we use a train-the-college concept, for example. [...] Then there is a forced shift leader rotation [...] That expands the knowledge of these people incredibly." (Case C, interview 1)<br>"Under circumstances, they all also attend seminars and training courses, then of course come together with employees of other companies, for example. Basically, they always have the opportunity to learn things that can be useful to us via newsletters and other channels." (Case D, interview 2) |
| Purposive positioning of boundary spanners | "There is the engineer I mentioned, and he is responsible for the areas of tool construction, construction and simulation. [...] He is the one who maintains the contacts, coordinates the experiments, and coordinates the cooperation in the projects with any research institutes. And there are also all kinds of cooperation with suppliers." (Case A, interview 1)<br>"[Process developers] are the link between the engineers and the masters in the workshop. And they are in-between." (Case A, interview 2).<br>"At the moment [the external knowledge flows into the organization] through me [top manager], [...] and then it is incorporated through these agile management meetings." (Case C, interview 1)<br>"And the smaller group discusses it from the technical side: where can we use it, whether it is feasible, how we integrate it in a certain process? In general, someone has an idea and plays it into the team meeting." (Case D, interview 2) |
| Cultivation of mechanisms facilitating intra-organisational information exchange | "We have very good experience of simply combining skill sets in that we say 'I have a process developer [...] Then I have a master toolmaker [...] And the construction department'. [...] Always bring these 3 areas to the table and say: 'First, we develop a basic concept together. How do we want to approach this thing? How do we want to build the tool?'" (Case A, interview 4)<br>"There is a team working together, always as a team. Because we have several interfaces that meet..." (Case A, interview 2)<br>"This is discussed and assessed by representatives of different disciplines, who sit at the same table." (Case D, interview 2)<br>"What is the basic structure of a machine, what should come out of it, [...] where do we see risks, where do we see possibilities? If they [production workers] are already there mentally, they are a clear step further, when the machine comes and then accept the thing. Because if they don't accept it, they say: 'it is not mine, it is yours'." (Case A, interview 1)<br>"…and of course these things are discussed again and again in our weekly meetings, what additional possibilities and ideas can be incorporated." (Case B, interview 1)<br>"There are a total of 5 structured meetings that run at different intervals. […] By the way, this is our very big instrument, which has triggered fantastic developments: the exchange between the different groups regarding knowledge. That works well. This is how we anchor current knowledge in people's heads." (Case C, interview 1)<br>"... for trade fairs that have taken place, there is then documentation in the form of a trade fair report, where we record all the things that may be important to us and then consider what we can do with them." (Case D, interview 1) |

(Table 2.5 Continued)

| Themes | Illustrative quotes (translated from German) |
|---|---|
| Alignment of organisational settings | "We are very task-oriented, so there are active tasks that are usually processed there. And if there is any time left or if there is a corresponding requirement, then it will be put on the table." (Case A, Interview 3).<br>"The people who organise production in the company, they have reserved part of their availability and time for questioning and further developing production as well. As a pool of ideas there are these regular meetings in the technical team." (Case D, interview 1)<br>"We can do a lot ourselves because we have a certain size. [...] That means I can really take one or two people completely off, even for a whole week, and I can have them trained." (Case C, interview 1)<br>"Due to our organisational structure, managing directors do not have much to do with day-to-day business, but have handed over responsibility to our employees. We defined our task in such a way that we are responsible for creating the right framework conditions so that the employees can do their job well. These are all important and necessary prerequisites for such a culture to emerge and to be effective. [...] To offer a completely open and positive information structure, i.e. to offer information, then to create the possibilities of regular meetings so that one can reach colleagues with their own ideas and suggestions." (Case D, interview 1) |

Taken together, the findings on the organisational components of AC in non-R&D firms reveal that, despite some commonalities across the four firms in their reliance on organisational mechanisms, these mechanisms are idiosyncratic to the respective firm in the specific way they are employed (cf. Eisenhardt and Martin, 2000). Each firm has its own optimal combination of several enabling mechanisms.

### *Comparing findings for non-R&D firms with traditional assumptions in AC research*

The revealed findings for non-R&D firms challenge the traditional assumptions underlying the AC concept. First, it is widely assumed that a firm must invest in in-house R&D to absorb any of the R&D output, and therefore that R&D-intensive firms are better equipped to absorb external knowledge (Cohen and Levinthal, 1990). Based on the analysed data from the case studies, it appears that AC is possible and can be successfully developed without investments in formal R&D. Deploying sufficient AC does not rely solely on R&D efforts. The analysed firms rely on diverse functional areas to compensate the missing R&D function and successfully exploit diverse organisational practices that foster communication and knowledge sharing between different departments and facilitate the integration and exploitation of assimilated knowledge. Moreover, not all

activities within an absorption process require R&D efforts (cf. Bogers and Lhuillery, 2011).

Second, a firm can succeed in acquiring, assimilating and exploiting relevant external knowledge even with limited personnel resources, especially with only a low share of highly educated personnel. On the one hand, a relatively low share of employees with university degrees can be compensated by positioning these employees effectively within an organisation to promote the AC process. On the other hand, the firm-specific tacit knowledge, experience and skills of employees rather than their formal qualifications seem to play a crucial role for non-R&D firms that pursue process innovations and rely on practical, applicable knowledge. Further enabling mechanisms include purposively enhancing human resources by means of qualification measures and training courses, encouraging employees to build personal external networks, and introducing an open, empowering corporate culture.

Third, the findings of the case studies challenge the assumption of path-dependency and the cumulative character of AC. The analysed non-R&D firms are able to overcome fixed trajectories and access distant knowledge domains even with limited personnel and financial resources. They are able to explore new technological areas on their own or by relying on the AC of long-standing external partners that provide them with relevant knowledge in "translated" form and help them with its assimilation. This ability to break traditional technological paths and go beyond familiar knowledge domains is becoming increasingly important for non-R&D firms, considering that recently even mature industries are experiencing rapidly changing market conditions and disruptive technological developments (Caloghirou et al., 2014).

## 2.5 CONCLUDING REMARKS

This paper explores AC beyond the R&D context and provides empirical insights into the interplay between individuals and organisational practices based on the analysis of the data from case studies of four German manufacturing firms that do not perform internal R&D activities. The results reveal that non-R&D firms pursue an individual-centred way of absorbing external knowledge. Their AC is based on a few key individuals and broadly anchored in different departments. To succeed with only a few key knowledge workers,

the analysed firms rely strongly on diverse organisational practices to effectively integrate individual capabilities into a collective outcome.

By highlighting the non-R&D perspective and combining the insights obtained from non-R&D firms with earlier research, this study broadens our understanding of AC and its underlying mechanisms. The obtained findings are not necessarily specific to non-R&D firms only, but they do call attention to some aspects of AC that are under-researched in the mainstream literature dominated by a R&D focus. These aspects include AC in the context of process innovations, the absorption of tacit, embedded knowledge, the organisational embeddedness of the AC process beyond a R&D unit, and the reliance on external AC. Moreover, non-R&D firms provide valuable insights that question the traditional assumptions underlying the AC concept. Future research can benefit from further examining the underlying assumptions in different contexts.

Besides showing that AC can be managed without formal R&D, this study particularly highlights the interplay between individual capabilities and enabling organisational mechanisms that foster technological AC in firms without R&D. The multi-level perspective and further exploration of the links between the individual and organisational components of AC is crucial to advance the AC concept theoretically. Additionally, by looking inside the "black box" of AC in non-R&D firms, this study provides information on the individual-level aspects of AC and on organisational practices. Therefore, it complements the research on the microfoundations of AC (e.g.; Distel, 2017; Lowik et al., 2017; Sjodin et al., 2019) as well as the on process-based stream of AC studies (e.g. Duchek, 2015b; Horvat et al., 2018; Patterson and Ambrosini, 2015).

In addition, the insights gained from the qualitative data analysis suggest that AC is a heterogeneous construct, and that a variety of successful AC patterns exist. Depending on the innovation objective and the nature of the relevant external knowledge, different specialised types of AC can be distinguished (e.g. Murovec and Prodan, 2009; Schmidt, 2010) that are linked to different mixes of resources and organisational mechanisms. Shedding light on the key enabling resources and mechanisms is an important contribution to the research on the antecedents of AC (e.g. Fosfuri and Tribó, 2008; Jansen et al., 2005; Lowik et al., 2017). Further investigation could be useful to discover

how the organisational- and individual-level antecedents differ between different types of AC, for example, between supplier-oriented and research-oriented AC, or between a focused, problem-driven approach and a broader, "slack" (Laursen, 2012) approach to knowledge search and absorption. Additionally, the insights into enabling organisational mechanisms can contribute to the development of a more comprehensive measurement approach to capturing AC in quantitative research.

For practitioners, the study provides insights into the successful management of AC that can help to support strategic decision-making. It gives examples and useful impulses of non-R&D-based mechanisms and describes how firms can develop, manage and enhance their AC, and thereby increase their innovativeness. A better understanding of the underlying mechanisms of knowledge absorption will become increasingly important for firms, especially in light of the challenges posed by highly competitive, rapidly changing and turbulent environments, knowledge intensification, the growing complexity of industrial production processes, and digital transformation.

# APPENDIX 1: CODING FRAME

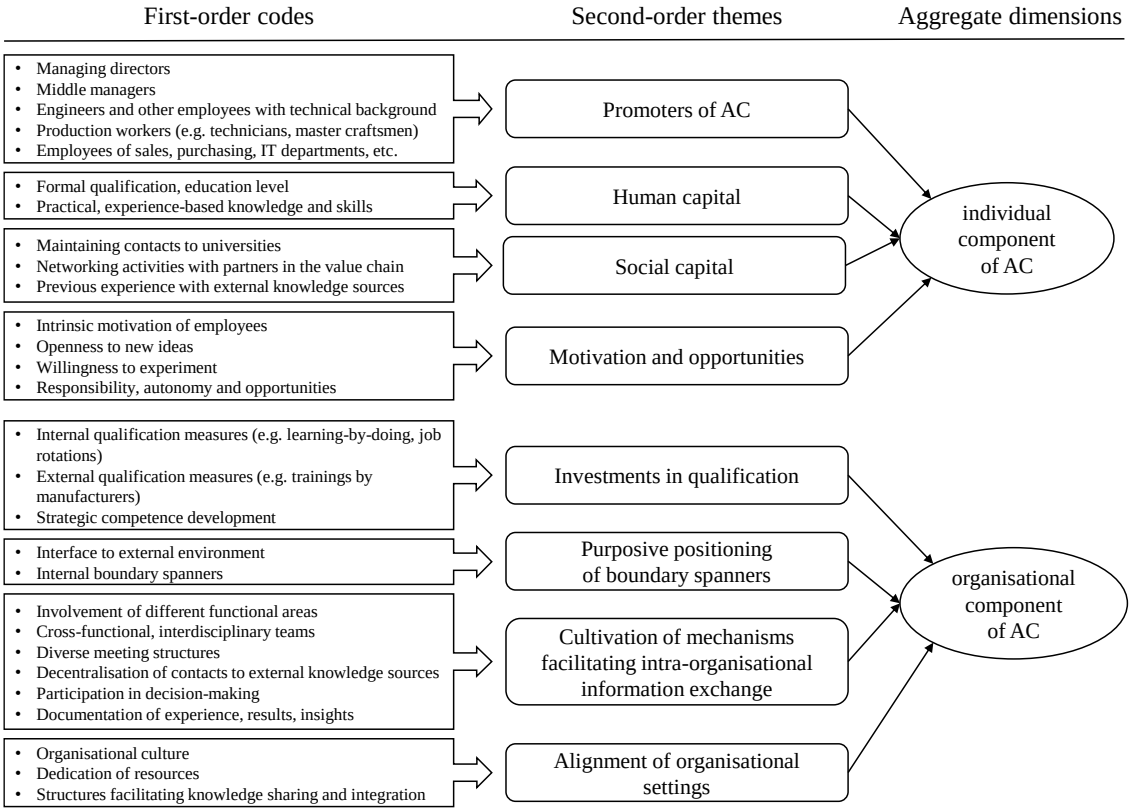


Figure 2.2: Coding frame for the qualitative content analysis (the author's own illustration)

## APPENDIX 2: INTERVIEW GUIDE

1. **Information about the interviewed person (position, area of responsibility, education)**

2. **Description of a problem-solving situation when external knowledge impulses were required and used**

Has your company introduced a new or changed the existing manufacturing process recently, for example by relying on new technology or method, when you had to rely on external knowledge impulses? Please describe the situation in more detail.

Where do the external impulses come from? How were the contacts with external partners established?

Who was responsible for searching for new ideas externally? Who else was involved?

What happens after they have found the relevant knowledge?

Who accessed, evaluated and processed this information?

How this knowledge was disseminated across the organisation? Which departments were involved?

Who exploited this absorbed external knowledge? How was this new knowledge integrated into the manufacturing process?

3. **Most important external sources of innovation impulses**

What are the other relevant external sources of knowledge for your innovation activities? Does your firm have contacts with universities or research institutes? How did these contacts come about? Which knowledge do you absorb/receive from research organisations? Has your firm participated in research projects? How does the cooperation with research partners look like?

Which role do your suppliers play?

Do you rely on impulses from customers for your innovation activities?

Which role do your competitors play?

**4. Key individuals and business units (departments) involved at the different stages of AC process**

Who has contacts with external partners or external knowledge sources? Which departments are involved?

In general, who is responsible for searching for new innovation impulses externally? Which qualification and prior related experience do these persons have?

Is the search for new knowledge a dedicated task or an integrated part of their daily operations?

How do they evaluate whether this knowledge impulse is relevant and valuable to be absorbed and processed? Who else is involved in the process of evaluation of newly acquired information? Who takes the final decision on whether the information should be processed further?

Who is responsible for processing and integrating the newly acquired knowledge? Which qualification and prior related experience do these persons have?

What is the role of production workers in the process of seeking external knowledge, assessing its potential and integrating it?

**5. Main enabling organisational mechanisms**

In your company, is there a systematic, formal process for how you search for and absorb new external knowledge for the innovation activities?

Do you have special meetings to share and discuss new ideas acquired externally? Who is involved? How often do these meetings take place?

In this concrete situation, was the prior related knowledge of involved employees sufficient to process the new information? Have the employees been trained? Which qualification measures do you generally rely on to expand and adapt the knowledge base of the employees?

Whether and how is the newly acquired knowledge usually documented and stored?

In your opinion, what are the most important factors that enable your company to access external impulses and successfully integrate them into the innovation process?

# CHAPTER 3

## Absorptive capacity and external search beyond R&D: Two modes of knowledge absorption in German non-R&D SMEs

**Abstract:** Drawing upon relevant external knowledge has become an essential part of firms' innovation success. When exploring how firms search and absorb external knowledge, scholarly attention has been largely devoted to large manufacturing firms from R&D-intensive industries. In order to obtain a more comprehensive picture of absorptive capacity and external search, this paper examines these concepts in the less studied, but highly relevant context of non-R&D-performing manufacturing SMEs. More specifically, based on recent cross-sectional data from a large-scale survey of German manufacturing firms, the study provides empirical insights into the openness and external search patterns of non-R&D and R&D SMEs. It reveals that non-R&D SMEs do not differ from R&D SMEs in terms of their openness and major external sources of innovation knowledge. However, compared with their R&D-performing counterparts, non-R&D SMEs are more likely to search for supplier-based knowledge and less likely to search for science-based knowledge. Furthermore, the study takes a deeper look at non-R&D SMEs and investigates two modes of absorptive capacity facilitating different search patterns. The results show that different search patterns are embedded in different functional areas and build on different prior knowledge stocks, captured by experience with different types of cooperation. The study supplements the literature on absorptive capacity by addressing two previously overlooked aspects: the heterogeneity in external knowledge sources, and the variety in firms' internal organisation of absorptive capacity.

**Keywords:** absorptive capacity; external search patterns; non-R&D innovators; SMEs

JEL Classifications O30, O32

## 3.1 INTRODUCTION

Drawing upon relevant external knowledge has become an essential part of the innovation process for firms, of any size and with any level of R&D intensity from all industrial sectors (Chesbrough and Crowther, 2006; Ehls et al., 2020; West and Bogers, 2014). It is widely acknowledged that benefitting from external knowledge should not be taken for granted (Cassiman and Veugelers, 2006). In order to strengthen their innovation activities and maintain competitive advantages by drawing upon external knowledge, firms need to develop absorptive capacity (hereafter AC) (Cohen and Levinthal, 1990; Zahra and George, 2002).

However, when exploring firms' AC and the role of external search, scholarly attention has been devoted to large firms from medium-high and high-technology industries, such as pharmaceuticals, biotechnology, semiconductor industries, chemicals, machinery and IT/software (e.g. Distel, 2017; Fabrizio, 2009; Lane and Lubatkin, 1998). Following the arguments by Cohen and Levinthal (1990), the majority of studies implicitly assume that firms performing R&D have more internal resources and are therefore better equipped to search for and absorb external knowledge (Hervas-Oliver et al., 2011). These firms are also more likely to benefit from the external knowledge in terms of positive effects on their innovation performance (Grimpe and Sofka, 2009; West and Bogers, 2014).

In contrast, hardly any attention has been paid to another, no less relevant group of firms, namely manufacturing firms without formal R&D (Hervas-Oliver et al., 2012; Moilanen et al., 2014; Muscio, 2007), even though the research suggests that these firms do not refrain from engaging in open innovations (Chesbrough and Crowther, 2006). Similarly, small and medium-sized enterprises (hereafter SMEs) have often been overlooked (Spithoven et al., 2013; Van de Vrande et al., 2010). Even though R&D-intensive SMEs have received some academic attention (e.g. Burcharth et al., 2015; Jong and Freel, 2010), the majority of SMEs do not engage in formal R&D (Rammer et al., 2009). Thus, there is little known so far about how manufacturing firms without formal R&D, and especially the SMEs among these, search for and absorb external knowledge. Low R&D investments are often interpreted as weak internal capabilities that results in a low ability to search for and absorb external knowledge (Mowery et al., 1996; Spithoven

et al., 2011). However, this assumption can be questioned because non-R&D firms do not necessarily have weak innovation capabilities (Arundel et al., 2008; Hirsch-Kreinsen, 2015; Som, 2012) or low knowledge intensity (Mendonça, 2009) (details are presented in the next section). Moreover, as argued by Moilanen et al. (2014), empirical findings regarding the weak AC of non-R&D firms may be biased by insufficient measures of AC. In other words, non-R&D firms do not necessarily have low AC, but researchers are relying on measurement approaches that are not appropriate for capturing AC in this group.

Given the innovativeness and relevance of non-R&D firms for European economies and their innovation systems (Arundel et al., 2008; Som, 2012; Tunzelmann and Acha, 2005), this study argues that the academic discussion on AC and external knowledge search should not be limited to high-tech industries and large R&D-intensive firms only. Existing findings from the few studies of a firm's openness to external knowledge in the low-tech context suggest that non-R&D firms may follow different search patterns and rely on different organisational resources to absorb external knowledge than their R&D-performing counterparts do (e.g. Grimpe and Sofka, 2009; Hervas-Oliver et al., 2012; Moilanen et al., 2014; Som et al., 2013; Spithoven et al., 2011). For example, Grimpe and Sofka (2009) show that firms from high-tech industries predominantly choose a search pattern directed at technological knowledge from universities and suppliers in order to achieve higher returns from knowledge inputs. Conversely, firms in low-tech industries rely much more on market-oriented search that targets knowledge from customers and competitors. Based on the comparison of non-R&D-intensive and high-R&D-intensive firms in the German manufacturing industry, Som et al. (2013) propose that, in the absence of formal R&D and an R&D department, non-R&D firms are likely to organise the process of knowledge absorption differently to R&D firms. First insights into the internal organisation of AC beyond R&D can be found in the study by Bogers and Lhuillery (2011), who describe the crucial role of marketing and manufacturing departments in addition to the R&D department for building AC oriented towards different knowledge sources. In a similar vein, a more recent study by Lee and Walsh (2016) calls attention to the importance of non-R&D units as another source of a firm's innovativeness that may form the basis for building organisational AC.

Therefore, by limiting AC to the R&D context only, the research runs the risk to overlook the variety in external search patterns and the variety of the ways in which firms build corresponding ACs. Accordingly, this study aims to provide novel empirical insights into manufacturing non-R&D-performing SMEs based on data from the German Manufacturing Survey 2015 (Jäger and Maloca, 2016). First, it explores whether there are differences between R&D and non-R&D SMEs in terms of the openness to external knowledge and the prevalence of knowledge inflows from customers, suppliers and research organisations in different fields of innovation. In this way, the study provides further insights into specialised search patterns (e.g. Chen et al., 2011; Koehler et al., 2012; Sofka and Grimpe, 2010) and highlights the heterogeneity of different knowledge sources for innovating firms (cf. Volberda et al., 2010). Second, to address the calls to explore the role of the type of external knowledge for AC (Schmidt, 2010; Song et al., 2018), this study takes a deeper look at the internal organisation of knowledge absorption associated with different search patterns. Drawing upon the STI and DUI modes of learning and innovation by Jensen et al. (2007), it distinguishes between STI and DUI modes of AC and analyses how these two modes facilitate different search patterns. The analysis focuses on the following underlying manifestations: (a) different functional areas that form the basis for the firm's AC process, (b) involvement in cooperation relationships, (c) and the role of human resources.

Overall, by examining the concepts of AC and external search in a less widely studied, yet highly relevant empirical setting, namely in non-R&D-performing manufacturing SMEs, this study supplements the current research by providing a more inclusive picture of AC and by obtaining insights into aspects that have been largely overlooked due to an excessive focus on R&D. In doing so, this study responds to the calls for further research to better understand and systematically analyse open innovation concepts, among them the concept of AC, in broader empirical settings beyond high-tech industries and firms (Chesbrough and Crowther, 2006; Vanhaverbeke et al., 2014, respectively Lane et al., 2006; Moilanen et al., 2014).

## 3.2 THEORETICAL BACKGROUND

### *Absorptive capacity and external knowledge search*

The concept of absorptive capacity was introduced by Cohen and Levinthal who defined it as the "ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990, p. 128). A number of later attempts were made to reconceptualise and refine the seminal concept (e.g. Lane et al., 2006; Song et al., 2018; Volberda et al., 2010; Zahra and George, 2002). One of the most prominent and widely used reconceptualisations of AC is that of Zahra and George (2002), who were the first to propose two distinctive but complementary components of AC: potential and realised AC. Firms possessing sufficient potential AC are more perceptive to external knowledge (Fosfuri and Tribó, 2008). The greater the firm's potential AC is, the larger the amount of absorbed knowledge that will enter the innovation process. However, to be able to leverage this newly absorbed knowledge efficiently and to apply it "to commercial ends", the firm requires realised AC. Innovation generation and improved firm performance, e.g. in terms of profitability or growth, materialise from realised AC (Zahra and George, 2002).

Despite a steadily growing body of empirical studies in the field of AC (Song et al., 2018), the research still has some shortcomings. This study aims to address at least two of them. First, AC is underresearched in the context of the Doing, Using and Interacting (DUI) mode of innovations (cf. Jensen et al., 2007). The majority of existing studies focus on AC in the Science, Technology and Innovation (STI) mode of learning, meaning they explicitly consider technological, scientific knowledge to be absorbed (Song et al., 2018) and concentrate on product innovations (Cassiman and Veugelers, 2006; Fosfuri and Tribó, 2008; e.g. Laursen and Salter, 2006) that are rooted in R&D efforts. The research conducted so far neither sufficiently examines the AC of tacit, process-oriented knowledge, marketing knowledge or manufacturing know-how (Lane et al., 2006; Volberda et al., 2010) nor does it properly explore AC in the context of innovation types that do not originate from R&D (Bogers and Lhuillery, 2011; Murovec and Prodan, 2009). There are only few studies that address the heterogeneity in the types of knowledge and consider specialised search patterns, such as science-driven, supplier-

driven and market-driven (e.g. Chen et al., 2011; Koehler et al., 2012; Sofka and Grimpe, 2010). These studies underscore that firms do not randomly combine different knowledge sources in their open innovation activities; they use a search strategy, which provides the directions and priorities for a knowledge search that reflects the firm's innovation objectives, the innovation potential of the targeted knowledge, and the external knowledge environment (Sofka and Grimpe, 2010). Similarly, studies considering different types of AC associated with different search patterns are rather rare (e.g. Murovec and Prodan, 2009; Schmidt, 2010; Vega-Jurado et al., 2008), even though the internal organisation of AC and underlying mechanisms may differ with respect to the type of external knowledge absorbed (Song et al., 2018). For instance, by analysing the Community Innovation Survey data for manufacturing firms in Spain and the Czech Republic, Murovec and Prodan (2009) found that the most important determinants for science-pushed AC are internal R&D and innovation cooperation, whereas the most important determinants of demand-pull AC are internal R&D, training of personnel, and attitude towards change. Further, by drawing upon the data from the German innovation survey of manufacturing and service firms, Schmidt (2010) revealed that while R&D-intensity is very important for scientific knowledge, its contribution to the absorption of industrial knowledge is less pronounced in the short term. However, these findings represent only the first insights into the role played by the characteristics of external knowledge for a firm's internal AC configuration. This calls for further investigation of the internal organisation of AC associated with different search patterns (Schmidt, 2010; Song et al., 2018).

Indeed, the second shortcoming of the AC research conducted so far is that the internal organisation of AC is not yet fully understood (Bogers and Lhuillery, 2011; Schmidt, 2010). Empirical insights into the internal organisation of AC beyond the R&D unit are sparse. Traditionally, R&D is widely acknowledged to be the main instrument of knowledge generation within a firm (Muscio, 2007; Sofka and Grimpe, 2010). Following the arguments presented by Cohen and Levinthal (1990), researchers commonly consider a firm's R&D efforts to be the main source of its absorptive capacity (Easterby-Smith et al., 2008; Lane et al., 2006; Murovec and Prodan, 2009). R&D staff are expected to be better equipped to drive the external knowledge search and absorb any relevant

knowledge in a more effective way (Escribano et al., 2009; Song et al., 2018). Nevertheless, while the role of R&D is important, focusing only on R&D-based activities is too restricted (Lane et al., 2006). Studies constraining AC to the R&D-based context gloss over the fact that even in high-tech firms, learning and knowledge absorption occur in other parts of the organisation as well (Lane et al., 2006). For example, the DUI-mode of learning and innovation does not originate from the R&D department, but is based on internal collaboration between different non-R&D functional areas (Lee and Walsh, 2016; Thomä and Zimmermann, 2020). An excessive emphasis on R&D is even more problematic for firms that have a low propensity to conduct formal R&D, such as SMEs (Muscio, 2007; Ortega-Argilés et al., 2009; Rammer et al., 2009). If R&D resources are limited, firms can develop their AC in different departments within the firm, such as manufacturing, marketing and design (Bogers and Lhuillery, 2011; Hervas-Oliver et al., 2012). This consideration is important to make the concept of AC relevant for the non-R&D-based context. However, studies examining the role of different functional areas for the process of knowledge search and absorption are rather rare (Bogers and Lhuillery, 2011; Van de Vrande et al., 2010). This demonstrates the need for further empirical studies.

### *Non-R&D firms*

Slightly more than half of European firms innovate successfully without performing formal R&D (Arundel et al., 2008). This implies that non-R&D firms[1], which do not conduct formalised R&D and do not report any formal R&D expenditure, are not less innovative per se than their R&D-performing counterparts (Kirner et al., 2009; Santamaría et al., 2009; Som, 2012). However, non-R&D firms differ remarkably from R&D firms in terms of their innovation resources and innovation objectives (Som, 2012;

1 In this paper, I focus on non-R&D-performing firms defined in terms of the absence of formal R&D expenditures (cf. Rammer et al. (2009); Som (2012) using the same approach). Nevertheless, even if I recognise the differences between such research categories as low-tech firms (e.g. Hervas-Oliver et al. (2012); Mendonça (2009); Spithoven et al. (2011)), non-R&D-intensive firms (e.g. Kirner et al. (2009)) and non-R&D performing firms, I draw upon insights from all these studies for the literature review. I assume that the patterns of innovation behaviour of these firms, even if they display a certain variation, show much more homogeneity when compared with firms with medium- or high-R&D-intensity.

Spithoven et al., 2011). Such differences are driven by firms' structural constraints and environmental context (Dooley and O'Sullivan, 2018). Indeed, non-R&D firms are predominantly present in mature low- and medium-tech industries (Heidenreich, 2009; Som, 2012), and the majority of them are small and medium-sized enterprises (Arundel et al., 2008; Hirsch-Kreinsen, 2015). Accordingly, as is the case for all SMEs, they are usually limited in terms of their financial and human capital, technological resources, infrastructure and know-how (Rammer et al., 2009; Van de Vrande et al., 2009). Consequently, to be able to make the AC concept relevant for non-R&D SMEs, the heterogeneity in innovation behaviour should be taken into account.

An important distinctive feature of non-R&D firms is that they do not usually innovate by building on the STI-mode of learning, which is associated with scientific, codified knowledge, internal R&D activities embedded in formal R&D units, and collaboration with external scientists (cf. Jensen et al., 2007). In contrast, the DUI-mode of innovation is much more common in these firms, which is characterised by reliance on tacit, practical, experience-based knowledge and close interaction with customers and suppliers (Jensen et al., 2007; Thomä and Zimmermann, 2020). Indeed, innovations in non-R&D firms do not usually result from systematic research or build on the latest scientific knowledge (Som, 2012). Instead, new ideas in these firms tend to be generated within the context of ongoing operations (Hirsch-Kreinsen, 2008) and rely on learning-by-doing, -using and -interacting (Hervas-Oliver et al., 2011). However, the innovation strategies of non-R&D firms are not homogeneous (Som, 2012), and previous research distinguishes several innovation patterns of firms without or with limited R&D activities.

Non-R&D firms do not always target product innovation as their main innovation objective (Som, 2012). If they do, their product innovations are more likely to aim at modifications and incremental changes and are concentrated within their core competences (Arundel et al., 2008; Hervas-Oliver et al., 2011; Hirsch-Kreinsen, 2008). In turn, particular importance is ascribed to technical process innovations (Hirsch-Kreinsen, 2015), where non-R&D and R&D firms show a similar performance (Hervas-Oliver et al., 2011; Santamaría et al., 2009). This type of innovation is based on production and technology competences and is more likely to result from customer demands and the experience-based knowledge and practical know-how of suppliers

(Heidenreich, 2009; Terjesen and Patel, 2017). Another group of non-R&D-performing firms pursue a "customer-oriented" or "market-driven" innovation strategy, aiming at a rapid response to customer needs (Grimpe and Sofka, 2009; Som, 2012) by offering fashion-oriented product design, using skilful branding strategies or providing expanded product-related services (Hirsch-Kreinsen, 2015).

In terms of the openness of non-R&D firms, empirical evidence suggests that external knowledge sources have become crucial for these firms as well (e.g. Heidenreich, 2009; Hirsch-Kreinsen, 2015). Some studies even argue that since the internal resources of non-R&D firms, especially non-R&D SMEs, are limited (Rammer et al., 2009) and internal innovation capability is constrained (Dooley and O'Sullivan, 2018), they have no other choice than to look beyond their organisational boundaries (Chesbrough and Crowther, 2006; Dooley and O'Sullivan, 2018; Ortega-Argilés et al., 2009; Santamaría et al., 2009). Results from existing empirical studies suggest that non-R&D firms rely primarily on customers and suppliers rather than on external R&D (Arundel et al., 2008; Heidenreich, 2009; Kirner et al., 2009). In this vein, by analysing the innovation patterns of German SMEs, Thomä and Zimmermann (2020) identified two non-R&D-intensive DUI groups of innovators: a supplier-dependent and a customer-oriented. Regarding the reliance on scientific knowledge, the findings are rather inconclusive for non-R&D firms. On the one hand, the findings of Spithoven and colleagues (2011) suggest that non-R&D firms might have problems in identifying and absorbing relevant scientific knowledge and hence need assistance from R&D-intensive intermediaries. However, the authors used R&D to measure a firm's AC. On the other hand, Hervas-Oliver et al. (2012) revealed that R&D expenditure does not contribute to explaining cooperation agreements to access knowledge from universities and research institutes. Som and colleagues (2013) showed that some non-R&D firms are able to absorb scientific knowledge, but only if this knowledge is of high strategic relevance for them. Accordingly, it would be misleading to conclude that, due to the lack of R&D, non-R&D firms limit the scope of their external knowledge search to industrial knowledge sources only. There is still a need for fine-grained insights into different search patterns in non-R&D firms, especially for those knowledge types where it is not intuitive that these firms have the appropriate AC.

***Hypotheses development***

Insights into how non-R&D firms organise their process of knowledge absorption in the absence of in-house R&D are still missing. Hence, there is a need for a better understanding of which organisational resources they rely on, and how these resources differ depending on the type and source of external knowledge. By considering AC as a frontend of the innovation process, this study suggests that the internal organisation of AC corresponds to the firm's innovation mode. More specifically, a firm's strategic orientation determines which knowledge is relevant and worth being absorbed, and which internal resources can be allocated to the AC process (Lane et al., 2006; Som et al., 2013). Following the innovation modes by Jensen et al. (2007), this paper distinguishes between (a) the STI mode enabling the absorption of scientific knowledge; and (b) the less institutionalised DUI mode enabling the absorption of knowledge from industrial sources, such as customers and suppliers.

For the absorption of external knowledge to lead to an innovation outcome, there should be a fit between the type of relevant external knowledge and the internal organisation of AC. Knowledge from different sources varies significantly in terms of novelty, complexity and applicability (for a detailed comparison, see Koehler et al., 2012; Vega-Jurado et al., 2008). The nature of external knowledge and the specific characteristics of a knowledge source force firms to specialise their search strategy accordingly and place different demands on their internal capabilities (Grimpe and Sofka, 2009). As a result, firms organise their ACs in different ways (Murovec and Prodan, 2009; Schmidt, 2010).

Firstly, the absorption of different types of knowledge is anchored in different functional areas within the firm (Bogers and Lhuillery, 2011). To be able to draw upon science-based knowledge, the firm has to undertake significantly greater efforts than for less complex and more applicable knowledge (Koehler et al., 2012). Higher-level AC that is associated with scientific knowledge is suggested to be based on the competences of the R&D department and the skills and experience of R&D personnel (Bogers and Lhuillery, 2011; Escribano et al., 2009). Obviously, non-R&D firms do not have a formal R&D department. Instead, it is likely that they rely on the competences of their engineering and design units to access complex science-based knowledge (cf. Hervas-

Oliver et al., 2012; Weidner, 2020). A firm's R&D or R&D-similar efforts may be less relevant if the external knowledge required for innovations relates to production processes or market trends (Schmidt, 2010). Cohen and Levinthal (1990) suggest that firms can build AC as a by-product of manufacturing operations. The manufacturing department is an important absorber of supplier knowledge (Bogers and Lhuillery, 2011) and is essential for non-R&D firms in the context of process innovations (Arundel et al., 2008; Lee and Walsh, 2016). Low-tech innovations happen in the context of ongoing production processes and are usually initiated by production engineers, technicians, master craftsmen and skilled workers (Hirsch-Kreinsen, 2008). Another important absorber within the firm is the marketing department as well as people "working on the front lines", which can be a valuable resource for learning about customer trends and new market developments (e.g. Hervas-Oliver et al., 2012). Considering the widespread "customer-oriented strategy" of non-R&D firms (Hirsch-Kreinsen, 2015; Som, 2012), the role of functional areas with close contacts to customers may be even more crucial in these firms compared with their R&D-performing counterparts.

Secondly, besides the functional areas, a necessary and crucial building block underlying AC is the firm's prior related knowledge stock (Cohen and Levinthal, 1990). The firm's knowledge base enables effective knowledge search and absorption if there is a superior overlap with the targeted external knowledge (Lane and Lubatkin, 1998; Song et al., 2018). In addition to R&D efforts, studies determined the organisational knowledge base through the accumulated experience with knowledge searches or previous interaction with external partners through cooperation (Fosfuri and Tribó, 2008; Murovec and Prodan, 2009; Zahra and George, 2002). Indeed, by interacting closely with external partners, a firm develops a common understanding and language , and a set of norms and routines (Fosfuri and Tribó, 2008; Terjesen and Patel, 2017). In this way, the more experience a firm has with a certain type of knowledge source, the more perceptive it is to this type of knowledge, and the more likely it is to seek and absorb this kind of knowledge in the future (cf. Vega-Jurado et al., 2008). Accordingly, firms that repeatedly cooperate on innovation projects with universities or research organisations have developed a sufficient level of absorptive capacity oriented towards research-based knowledge (Fosfuri and Tribó, 2008). They are more likely to search for research-driven

innovation impulses than firms that do not have experience with this type of cooperation. Further, the accumulated experience from R&D cooperation differs from the experience gained from cooperation in other functional areas, such as cooperation on production, purchasing or services.

In addition, it is widely acknowledged that highly qualified and competent employees are better at absorbing knowledge from outside the firm (Cohen and Levinthal, 1990; Lane et al., 2006; Schmidt, 2010). Accordingly, firms with larger shares of highly educated and trained employees have higher levels of AC (Schmidt, 2010; Vega-Jurado et al., 2008). Considering the differences between knowledge sources in terms of complexity, this effect is likely to be more prominent in the search for scientific knowledge.

In the light of the arguments presented above, the following hypotheses are formulated:

*Hypothesis 1: Customer-driven and supplier-driven search patterns are associated with the DUI mode of absorptive capacity.*

Hypothesis 1a: Departments with close customer contact (e.g. customer services) are positively related to customer-driven search.

Hypothesis 1b: The manufacturing department is positively related to supplier-driven search.

Hypothesis 1c: Non-innovation types of cooperation are positively related to customer-driven and supplier-driven search patterns.

*Hypothesis 2: Science-driven search is associated with the STI mode of absorptive capacity.*

Hypothesis 2a: The engineering department is positively related to science-driven search.

Hypothesis 2b: Innovation cooperation with research organisations is positively related to science-driven search.

Hypothesis 2c: Highly educated employees are positively related to science-driven search.

## 3.3 METHOD

### *Data and sample*

This paper analyses empirical data from the German Manufacturing Survey 2015. This is a regular, questionnaire-based postal survey that has been conducted by the Fraunhofer Institute for Systems and Innovation Research ISI since 1993 (cf. Kirner et al., 2009). The

survey targets firms from all manufacturing sectors (based on NACE classification rev. 2) with at least 20 employees. It provides a representative cross-section of the entire manufacturing industry in Germany (Jäger and Maloca, 2016). The 8-page questionnaire accesses different fields of innovation and performance indicators, and includes questions about the different knowledge sources of innovation impulses and firms' cooperation activities.

The analysis focuses on non-R&D-performing firms. These firms report neither intramural nor extramural R&D activities, and their formal total R&D expenditure amounted to 0% of the sales in year 2014[2]. This is in line with innovation studies focusing on non-R&D performers or non-R&D innovators (e.g. Arundel et al., 2008; Moilanen et al., 2014; Rammer et al., 2009). The analysis is also limited to firms with fewer than 250 employees, in line with the European Commission's standard definition of small and medium-sized enterprises.

The data set from the year 2015 covers 1090 SMEs, including 651 non-R&D-performing SMEs. Appendix 1 provides a comparison of non-R&D and R&D SMEs in terms of firm size and industry affiliation.

### *Statistical methods and measures*

Bivariate and multivariate analyses were conducted. In the first step, a bivariate analysis was performed to explore the openness to external knowledge sources, and to describe the major external sources of innovations in non-R&D SMEs in comparison with R&D SMEs. In the second step, the analysis focuses on the non-R&D firms and binominal logistic regressions are run to test the hypotheses.

#### *Dependent Variables*

The paper distinguishes three search patterns that rely on knowledge inflows from customers and users, suppliers, and research institutes and universities. In previous

2 Since previous research has shown that internal and external R&D expenditure often complement each other (e.g. Rammer et al. (2009); Schmiedeberg (2008)), the question in the questionnaire and the corresponding variable account for the total R&D expenditure of a firm and consider both internal and external R&D.

studies, search patterns, or external knowledge inflows, are usually measured based on questions about the use and importance of external knowledge from different actors for developing innovations (e.g. Laursen and Salter, 2006; Terjesen and Patel, 2017). While the majority of previous studies operationalised external search strategies based on their breadth and depth and ignored their direction, this paper builds on the theoretical arguments and empirical results of Koehler et al. (2012) and Sofka and Grimpe (2010), and distinguishes three distinct search patterns: customer-driven, supplier-driven and science-driven.

In the German Manufacturing Survey 2015, the related question was phrased as follows: "Where do the major impulses or ideas for innovations come from in the following four innovation areas?" Four internal (engineering, customer service, manufacturing, and management) and four external (customers or users, suppliers, research institutes or universities, and business and management consulting) sources of innovation impulses are distinguished. These sources are stratified into four fields of innovation (new products, new technical processes, new product-related services, and new organisational concepts). A firm could select a maximum of three sources per innovation field.

The regression models were estimated for three dependent variables that were constructed as follows. *Customer-driven search pattern* is set to one, if one of the major impulses for innovations in at least one of the four fields of innovation comes from customers or users. The same logic was applied to construct two other dependent variables: *supplier-driven and science-driven search patterns*.

*Explanatory and Control Variables*

To be able to recognise the importance of knowledge ("major impulses or ideas") and rely on this knowledge source for innovations, the firm must possess a certain level of AC oriented towards this kind of knowledge (cf. Fosfuri and Tribó, 2008; Vega-Jurado et al., 2008). The question underlying the construction of the dependent variables does not show whether the firm successfully developed any innovations based on these knowledge inputs (exploitation dimension). Therefore, this paper focuses primarily on the potential component of a firm's AC: its ability to search for and identify relevant

valuable external knowledge, and assimilate it (Cohen and Levinthal, 1990; Song et al., 2018; Zahra and George, 2002). The following three underlying components of a firm's (potential) AC were included in the models as explanatory variables: functional areas, involvement in cooperation and human resources.

To capture *functional areas* where the processes of external knowledge search and absorption are anchored, the major internal sources of innovation impulses were used as a proxy. Following functional areas were considered in the analysis: engineering department, customer service, and manufacturing. The underlying assumption is that functional areas that initiate or drive innovations internally are the main carriers of the relevant knowledge for innovations (in a certain field of innovation) and therefore the main internal drivers of external knowledge search and absorption. Employees working in these functional areas are assumed to actively search for relevant knowledge externally, evaluate and assimilate it, in order to deepen the pool of information available to them.

*Involvement in formal cooperation* was measured using two dummy variables: innovation cooperation with research organisations (research institutes and universities), and other types of cooperation, such as purchasing, production, sales/distribution, or service. It is worth emphasizing that innovation cooperation with external R&D organisations should not be confused with externally contracted R&D. R&D contracting can be seen as a "normal" market transaction (i.e. exchanges money for knowledge) (Schmiedeberg, 2008). When a firm requires innovative knowledge that is not readily found on the market, it is likely to choose to cooperate in R&D (i.e. knowledge exchange). R&D cooperation establishes a reciprocal relationship, and hence goes far beyond purely contracting out R&D activities (Som, 2012). In the questionnaire of the German Manufacturing Survey, the question on R&D cooperation refers to collaborative work with research organisations to develop a new product or technology, and not to a statistical measure of the expenditure devoted to contracted R&D.

Measures of *human resources* often refer to the level of education and training of a firm's employees. Commonly used indicators are the share of employees with tertiary degrees, share of engineers, and share of employees in the R&D department (e.g. Mowery et al., 1996; Vega-Jurado et al., 2008). In this paper, human resources were captured by the share of university graduates in total employees.

The regression models also include a number of controls, such as *firm size, position in the value chain, and labour intensity* (cf. Kirner et al., 2009; Som, 2012). Additionally, the models include the *R&D intensity of the sector*: firms belonging to sectors with low-technology intensity, and firms belonging to sectors with medium- and high-technology intensity (cf. Schmidt, 2010). Detailed definitions of the explanatory and control variables are summarised in Appendix 2.

## 3.4 RESULTS

### *Descriptive results*

Table 3.1 presents the descriptive results for the openness to external knowledge sources in four fields of innovation. On the one hand, the table shows a similar level of openness of innovation activities in non-R&D and R&D SMEs. For each field of innovation, the shares of firms relying on external inflows, solely or in combination with internal knowledge sources, are nearly the same for non-R&D and R&D SMEs. Moreover, the shares of firms relying exclusively on external sources to develop new products and new production processes are even higher among non-R&D firms (12% of non-R&D SMEs compared with only 6% of R&D SMEs for product innovation; and 6% compared with 3%, respectively, for process innovation). On the other hand, the degree of openness varies strongly between the fields of innovation. Product innovations are the most open (90% of non-R&D and 91% of R&D SMEs rely on external knowledge sources here), whereas the corresponding shares in the three other fields are substantially lower. Overall, the strategy of combining internal and external sources dominates in all four fields of innovation.

The first row in Table 3.2 shows the prevalence of different knowledge search patterns in non-R&D and R&D SMEs. It is obvious that customers are the most important source of external knowledge for both groups of firms, followed by suppliers, and then research organisations. With regards to customers, there is no statistically significant difference between non-R&D and R&D SMEs (90% of non-R&D firms and 91% of R&D firms). The last four rows in the table reveal that the importance of customers are similar for non-R&D and R&D SMEs across different fields of innovations. Both groups are

likely to draw upon customer-based knowledge when developing product or product-related service innovations. A fifth of the firms, however, also rely on customers for process innovations.

Table 3.1: Openness in different types of innovations in non-R&D and R&D SMEs

| Innovation field | | only internal knowledge sources | internal and external knowledge sources | only external knowledge sources | N |
|---|---|---|---|---|---|
| Product | non-R&D firms | 10% | 78% | 12%* | 573 |
| | R&D firms | 9% | 85% | 6%* | 431 |
| Technical process | non-R&D firms | 32% | 61% | 6%* | 551 |
| | R&D firms | 34% | 63% | 3%* | 413 |
| Product-related service | non-R&D firms | 23% | 65% | 12% | 443 |
| | R&D firms | 23% | 67% | 10% | 357 |
| Organisational | non-R&D firms | 47% | 50% | 3% | 518 |
| | R&D firms | 46% | 51% | 2% | 383 |

Source: German Manufacturing Survey 2015, Fraunhofer ISI; own calculations
Notes. No association is statistically significant (at the .05 level) when distinguishing between two categories: 0= relying only on internal knowledge sources and 1=relying on external knowledge sources (solely or in combination with internal).
* = A statistically significant association between the type of firm (non-R&D- and R&D-performing SME) and the openness of innovation activities (3 categories) in a given innovation field based on a chi-square test of independence (at the .05 level).

On the other hand, statistically, non-R&D SMEs are more likely to rely on suppliers than R&D SMEs do (56% of non-R&D firms versus 45% of R&D firms). As expected, suppliers are primarily relevant for triggering process innovations. However, it is worth noting that non-R&D SMEs draw upon knowledge from suppliers more often than R&D SMEs when developing other types of innovations, e.g. product and product-related service innovations.

Of the three analysed knowledge sources, inputs from external research are used the least often, even among R&D firms. Non-R&D SMEs, as expected, have a much lower reliance on research-based inflows than their R&D counterparts (18% of non-R&D firms versus 40% of R&D firms). Further, compared with R&D SMEs, research-based inputs among non-R&D SMEs seem to be more important for technical processes than for product innovations.

Table 3.2: Importance of impulses from different external partners across different innovation fields

| Innovation field | Customers and users | | Suppliers | | | Research institutes and universities | | |
|---|---|---|---|---|---|---|---|---|
| | non-R&D SMEs | R&D SMEs | non-R&D SMEs | R&D SMEs | | non-R&D SMEs | R&D SMEs | |
| All fields of innovation | 90% | 91% | 56% | 45% | * | 18% | 40% | * |
| Product | 79% | 82% | 20% | 12% | * | 6% | 21% | * |
| Technical process | 20% | 18% | 43% | 35% | * | 10% | 18% | * |
| Product-related service | 64% | 68% | 15% | 9% | * | 4% | 4% | |
| Organisational | 19% | 15% | 11% | 7% | * | 6% | 14% | * |

Source: German Manufacturing Survey 2015, Fraunhofer ISI; own calculations

Notes. The numbers show the share of firms selecting a specific external knowledge source as one of the major sources for innovation impulses in at least one innovation field (first row) or in a given innovation field (last four rows).
Row percentages are not equal to 100% because of multiple answers.
* = A statistically significant association between the type of SME (non-R&D- and R&D-performing) and the reliance on a specific external knowledge source in at least one innovation field, respectively, in a given innovation field based on a chi-square test of independence (at the .05 level).

### *Regressions*

To test the hypotheses, logit regression analyses were performed for the subsample of non-R&D SMEs to estimate the effects of the independent and control variables on the probability of a firm to pursue customer-driven, supplier-driven or science-driven search. The models explain between 8.4% and 23.6% of the variance (Nagelkerke R2) (see Table 3.3). Appendixes 3 and 4 present the descriptive statistics and correlation analysis. No single bivariate correlation exceeds an absolute value of 0.4, and the majority of bivariate correlations are below 0.3. Therefore, there are no serious concerns about multicollinearity.

The results of Model 1 show that *customer service* is an important variable for explaining the firm's propensity to draw on customer-based knowledge. It has a significant positive coefficient. Therefore, the data supports Hypothesis 1a. However, the data of Model 2 provide no empirical support for Hypothesis 1b. There is no statistically significant effect of *manufacturing* on supplier-driven search, meaning that, despite providing major innovation impulses, this functional area has no impact on the propensity to draw on supplier knowledge. Finally, the data partly support Hypothesis 1c. *Non-innovation types of cooperation*, such as cooperation in purchasing or production, increase the propensity to search for supplier-based knowledge.

Regarding science-driven search (Model 3), *the engineering department* relates positively and significantly to the search for science-based knowledge, i.e. external R&D knowledge is likely to be used to complement internally generated knowledge. Thus, Hypothesis 2a is supported. Besides engineering, the *customer-service department* appears to have an even stronger positive effect. Further, the results show that *innovation cooperation with research organisations* increases the propensity to draw on scientific inflows, supporting Hypothesis 2b. Contrary to the expectations formulated in Hypothesis 2c, the *qualification level of employees* is not significant for explaining the propensity to search for external scientific knowledge. The effect is also not significant in two other models.

Table 3.3: Results of the binary logistic models for non-R&D SMEs

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | Customer-driven | | Supplier-driven | | Science-driven | |
| Variables | Coeff. | SE | Coeff. | SE | Coeff. | SE |
| Engineering | -0.129 | .713 | -0.107 | .615 | 0.599** | .038 |
| Customer service | 0.939*** | .008 | 0.309 | .131 | 0.767*** | .008 |
| Manufacturing | 0.534* | .098 | 0.213 | .341 | -0.070 | .822 |
| Innovation cooperation with research organisations | 0.235 | .577 | -0.042 | .861 | 1.856*** | .000 |
| Other types of cooperation | -0.201 | .512 | 0.686*** | .000 | 0.202 | .454 |
| Qualification level of employees | 0.005 | .782 | 0.001 | .955 | 0.015 | .381 |
| Firm size (log) | 0.758*** | .005 | -0.167 | .285 | -0.338 | .117 |
| Low-tech sector | -0.877* | .064 | 0.625*** | .008 | 1.110*** | .002 |
| Producer of finished goods | -0.415 | .215 | 0.248 | .227 | -0.602** | .035 |
| Labour intensity | -0.001 | .890 | 0.001 | .882 | 0.013* | .099 |
| Intercept | -0.442 | .727 | -0.369 | .630 | -3.056*** | .008 |
| Observations | 472 | | 472 | | 472 | |
| Nagelkerke R2 | 0.138 | | 0.084 | | 0.236 | |
| - 2 log-lik. | 301.300 | | 619.721 | | 371.653 | |
| % correctly classified | 88.6% | | 62.7% | | 82.8% | |

Source: German Manufacturing Survey 2015, Fraunhofer ISI; own calculations
Notes. Coefficients and standard errors are reported. Level of significance: *** p <0.01; ** p<0.05; *p<0.1.

Analysing the structural variables reveals that their effects and significance vary between search patterns. This suggests there is no one type of non-R&D firm with certain structural characteristics that is more open in general, i.e. is more likely to rely on external knowledge. Larger SMEs and firms from high-tech sectors are more likely to draw on

customer-based knowledge. In contrast, SMEs from low-tech sectors tend to draw on supplier- and science-based knowledge. The propensity to pursue science-driven search is also higher for firms with a higher labour intensity of production, but lower for the producers of finished goods.

## 3.5 Discussion and Implications

This study supplements the current research on absorptive capacity and external knowledge search by examining the concepts in a less widely studied, but no less relevant empirical setting, namely in non-R&D-performing manufacturing SMEs. By analysing recent data from a large-scale quantitative survey of German manufacturing firms, the study aims to find out whether non-R&D SMEs differ in their openness and prevalent search patterns from their R&D counterparts, and how they organise the absorption of different types of external knowledge in the absence of formal R&D.

First, the descriptive findings indicate that non-R&D-performing SMEs are not that different from their R&D performing counterparts in terms of their openness in innovation and the prevalence of different external knowledge search patterns. They demonstrate a similar openness to external knowledge across all four fields of innovation as R&D SMEs do. This finding is in line with arguments from the previous research on SMEs and non-R&D firms that reliance on external knowledge sources is a promising approach for their innovation activities (Dooley and O'Sullivan, 2018; Santamaría et al., 2009; Spithoven et al., 2013; Van de Vrande et al., 2010).

Moreover, it appears that non-R&D and R&D SMEs share similar search behaviour in terms of major external sources, a finding which does not support the results by Grimpe and Sofka (2009). Both groups are likely to draw upon industrial knowledge sources associated with the DUI mode of innovation, and less likely to rely on scientific knowledge linked to the STI mode of innovation. In fact, customer inflows are by far the most sought after source and scientific knowledge the least. This result might suggest that customer-based knowledge requires low efforts to be absorbed, especially if customer needs are considered a quickly convertible source of ideas for incremental product innovations (cf. Koehler et al., 2012). In turn, science-based knowledge is more

challenging to be processed due to its greater distance from direct application (cf. Vega-Jurado et al., 2008).

On the other hand, the findings on technological knowledge from suppliers and science suggests that the reliance on these two sources is linked to a firm's formal R&D. Compared with R&D SMEs, non-R&D SMEs are more likely to target supplier-based knowledge. This is consistent with previous findings suggesting that supplier-driven search is typical for non-R&D-performing process innovators (e.g. Som, 2012). In turn, these firms are less likely to search for science-based knowledge. At first glance, this result is in line with the commonly held view that investments in intramural R&D allow firms to better exploit R&D outputs generated outside the firm (Cohen and Levinthal, 1990; Spithoven et al., 2011). In this sense, due to their poorer abilities, non-R&D firms are forced to substitute scientific knowledge by more applicable and immediately relevant supplier knowledge. However, another way to interpret this result is to acknowledge that non-R&D SMEs do not have poorer, but rather different abilities to search and absorb external knowledge. The differences in the innovation patterns of these firms (e.g. Som, 2012) are likely to shape the intensity of usage of scientific inflows as strategically relevant sources of knowledge. In this vein, a relevant share of non-R&D SMEs, namely 18 %, have developed the necessary internal capabilities to access and absorb science-based knowledge. Considering the costs of external knowledge search and absorption (West and Bogers, 2014), it is likely that, despite their structural limitations, this group of non-R&D SMEs pursues this "more advanced" search pattern because of its high strategic relevance to them (cf. Som et al., 2013). Hence, this finding contradicts the widespread assumption that R&D activities are required for this (Cohen and Levinthal, 1990; Murovec and Prodan, 2009). This has an important implication for the further development of the AC construct by calling attention to the role of a firm's innovation orientation and managerial choices.

The above findings have also implications for the debate in the open innovation literature on the "substitution effect" between external sources and internal R&D (Laursen and Salter, 2006; West and Bogers, 2014) by providing a different angle. The findings of this paper show that in the absence of formal R&D, only a very low share of non-R&D SMEs actually substitute their constrained internal innovation resources by

relying exclusively on external knowledge inflows, even if this share in the fields of product and process innovation is higher than among R&D SMEs (see Table 3.1). Apparently, the lack of R&D does not reduce the interest in external sourcing or constrain the access to external sources. The firms without R&D are still able to identify and access relevant knowledge sources, and, hence, seem to possess potential AC. However, it is still possible that the lack of R&D reduces the value of such use of external knowledge (cf. West and Bogers, 2014). With the data used, it is not possible to conclude whether the non-R&D SMEs can also successfully leverage the absorbed knowledge to develop innovations or enhance their performance. West and Bogers (2014) suggest that the intention to pursue external search will cause firms to seek and develop the competences necessary to make this search effective; and the presented findings for science-driven search in non-R&D SMEs underpin this argument. This opens up the possibilities for further empirical investigation.

Second, this paper demonstrates empirically that there are differences between search patterns in terms of the underlying manifestation of AC. By arguing that AC does not happen in a vacuum, but is an integral part of the firm's innovation process, the study attempts to transfer the STI/DUI concept by Jensen et al. (2007) to the context of AC and show how two modes of AC are linked to different search patterns. In detail, the multivariate results demonstrate that in non-R&D SMEs the search for external knowledge from different sources is anchored in different functional areas. For example, a search pattern oriented towards customer knowledge appears to be embedded in the customer service department. To draw upon scientific knowledge, non-R&D SMEs rely on their engineering and customer service departments. Customer service is likely to trigger the innovation process by collecting and championing the needs of customers. On the other hand, the direct contact with research organisations and universities takes place in the engineering department, whose employees are better qualified to acquire, process and integrate the complex, technological knowledge from universities in order to develop innovations (cf. Weidner, 2020). A possible explanation for the broader footing of science-driven search is that cross-functional collaboration between different departments might be a necessary condition for non-R&D firms to successfully absorb more advanced and complex knowledge from research organisations (cf. Horvat et al., 2018). A rather

unexpected finding is that manufacturing does not seem to play an important role for the absorption of external knowledge in non-R&D firms, whose innovations are often characterised by informal and incremental problem-solving and experimentation on the shop floor (Hervas-Oliver et al., 2012). The contributions of the different functional areas to AC has implications for R&D firms as well. The DUI mode of AC is also present in R&D firms and future research needs to explore this in more detail.

The findings on cooperation also uphold the idea of the STI/DUI modes of AC. The results revealed that science-driven search is strongly related to innovation cooperation with research organisations (cf. Murovec and Prodan, 2009), whereas supplier-driven search is associated primarily with other, non-innovation types of cooperation. The results are consistent with the theoretical argument that previous formal cooperation relationships have positive impacts on and shape the locus of external knowledge search (Fabrizio, 2009). Moreover, since the data used cannot determine causality, the opposite direction is also plausible: firms actively searching for external innovation impulses are more likely to find suitable collaboration partners. This does not contradict the findings in this paper, but rather emphasises that searching for innovations externally, both formally and informally, is a dynamic and cumulative process.

Further, the study revealed that the qualification level of employees does not explain the propensity of non-R&D SMEs to follow any of the search patterns. This finding contradicts traditional research that suggests a high share of graduates as a supplementary measure of a firm's AC (e.g. Vega-Jurado et al., 2008). This might indicate that having highly qualified employees is a prerequisite, but not a sufficient condition for firms to conduct external knowledge search. The decisive factor for AC in non-R&D firms is likely to be not just the number of graduates, but how effectively they are integrated into the process of knowledge absorption (cf. Jones, 2006).

These multivariate results raise the question whether internal formalised R&D activities are a necessary condition for developing a sufficient level of AC. This has important implications for the debate on the measurement of AC (e.g. Flatten et al., 2011), especially considering the rather contradictory previous findings on the role of R&D as a predictor of AC (Flatten et al., 2011; Murovec and Prodan, 2009). Making a distinction between the STI and DUI modes of AC enables the assumption that, by relying on the

most widely used R&D-related indicators (Song et al., 2018; West and Bogers, 2014), researchers are likely to capture only part of the picture, namely the STI mode of AC in R&D-performing firms. Consequently, such an approach neglects non-R&D firms and underestimates the DUI mode of AC, which relates to customer- and supplier-driven search patterns that are far more prevalent, even in R&D firms. Formal R&D efforts can be complementary to developing the DUI mode of AC, but are not a decisive antecedent.

Last but not least, the results of this study lend credence to the idea that the absence of R&D does not imply lower levels of knowledge intensity in innovations. This suggests that the research should not underestimate the innovativeness of non-R&D firms in terms of their ability to search for and absorb relevant external knowledge. Considering the specifics of non-R&D firms in analyses would make it possible to paint a more exhaustive picture of search behaviour and absorptive capacity by highlighting the variety in search patterns, as well as the variety in the underlying organisational resources and capabilities that facilitate the search for external knowledge.

Apart from the theoretical contributions, the findings of this paper have several implications for decision-makers in companies. First, companies can benefit from widening their search space for external opportunities and purposely consider industrial partners as a valuable source of technological knowledge that is less complex and more applicable than science-based knowledge. Second, the paper stresses the importance of making strategic use of different functional areas for developing search and absorptive capabilities. In this vein, firms, even R&D-performing firms, can benefit from attaching value to non-R&D-based resources when exploring options for how to access relevant external knowledge. Thus, the paper urges decision-makers to strengthen the absorptive capacity of the relevant business units besides R&D departments and encourage them to play an active role in the knowledge search process. To better deal with knowledge complexity, firms with limited R&D resources can combine the forces of several business units within the company. Different business units each have their own unique resources, capabilities and experience, and can therefore contribute to different search paths.

### *Limitations and future research*

The study has several limitations that open up opportunities for future research. First, by being based on the quantitative analysis of survey data, the results of this study have certain limitations typical for a national survey. In particular, given the cross-sectional character of the data, this study could only establish associations between a search pattern and manifestations of the related AC mode and could not make any causal inferences about the relationship. Assuming that the relationship between knowledge search and absorptive capacity is symbiotic and has a dynamic, cumulative character, future research could provide more insights into the interplay between them by adopting a longitudinal research design. Further, the study could be extended by exploring the links between different external search patterns in detail, whether and how firms combine them, and what the underlying AC process looks like if they are combined. This type of research would benefit from a qualitative approach, especially at the initial stage. Finally, this study focuses primarily on the potential component of AC. Future research could build on these findings and explore the realised component of AC in non-R&D firms, how they gain value and capitalise external knowledge inflows. Furthermore, it could be relevant for future research to consider the moderator role of a proper mode of AC when exploring the effects of different search patterns on outcomes in product, process and service innovations.

# APPENDIX 1

Table 3.4: Sectoral affiliation and firm size of R&D and non-R&D SMEs

| | Non-R&D SMEs | R&D SMEs | Total N |
|---|---|---|---|
| **Number of employees*** | | | |
| 20 to 49 employees | 68% | 32% | 533 |
| 50 to 99 employees | 59% | 41% | 299 |
| 100 to 249 employees | 44% | 56% | 258 |
| **Affiliation to low-, medium-, high-tech sectors on basis of NACE rev. 2 (3-digit level) (by Gehrke et al., 2013)*** | | | |
| Non-research-intensive low-tech sectors | 69% | 31% | 725 |
| Research-intensive medium-tech sectors | 48% | 52% | 286 |
| Research-intensive high-tech sectors | 23% | 77% | 79 |
| **Sectoral affiliation (NACE Rev. 2, 2-digit level)*** | | | |
| Manufacture of food products, beverages and tobacco (10 11 12) | 75% | 25% | 101 |
| Manufacture of chemical and pharmaceutical products (20 21) | 38% | 63% | 56 |
| Manufacture of rubber and plastic products, and other non-metallic mineral products (22 23) | 64% | 36% | 163 |
| Manufacture of basic metals and fabricated metal products (24 25) | 70% | 30% | 257 |
| Manufacture of electronic and electrical equipment (26 27) | 33% | 67% | 121 |
| Manufacture of machinery and transport sector (28 29 30) | 50% | 50% | 205 |
| Other sectors (13-19 und 31-33) | 68% | 32% | 187 |
| **Total** | 651 | 439 | 1090 |

Source: German Manufacturing Survey 2015, Fraunhofer ISI; own calculations

Notes. * = Differences between R&D- and non-R&D-performing SMEs are statistically significant based on a chi-square test of independence (at the .05 level).

# APPENDIX 2

Table 3.5: Description of independent variables

| Variable | Description | Values |
|---|---|---|
| **Explanatory variables** | | |
| *Functional areas* | | |
| Engineering | One of the major impulses or ideas for innovations in at least one of the four innovation fields comes from engineering | 1 = yes;<br>0 = otherwise |
| Customer service | One of the major impulses or ideas for innovations in at least one of the four innovation fields comes from customer service | 1 = yes;<br>0 = otherwise |
| Manufacturing | One of the major impulses or ideas for innovations in at least one of the four innovation fields comes from manufacturing | 1 = yes;<br>0 = otherwise |
| *Involvement in cooperation* | | |
| Innovation cooperation with research organisations | The firm cooperates in the area of R&D with research organisations (universities or research institutes) | 1 = yes;<br>0 = otherwise |
| Other types of cooperation | The firm cooperates in at least one of the following areas: purchasing, production, sales/distribution, or service | 1 = yes;<br>0 = otherwise |
| *Human resources* | | |
| Qualification level of employees | Share of university graduates among employees | % |
| **Control variables** | | |
| Firm size (log) | Logarithm of the number of employees | log |
| Low-tech sector | The firm operates in non-research-intensive, low-tech sectors (by Gehrke et al., 2013) | 1 = yes;<br>0 = otherwise |
| Producer of finished goods | With regard to the main line of products, the firm is predominantly a producer of finished products for end consumers or for industrial businesses | 1 = yes;<br>0 = otherwise |
| Labour intensity | Share of employees working in manufacturing and assembly | % |

Source: German Manufacturing Survey 2015, Fraunhofer ISI

# APPENDIX 3

Table 3.6: Descriptive statistics

| | All SMEs (N=830) | | | | Non-R&D SMEs (N=472) | | R&D SMEs (N=358) | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | Mean | Std. | Min | Max | Mean | Std. | Mean | Std. | |
| Engineering [a] | 0.56 | | 0 | 1 | 0.42 | | 0.75 | | * |
| Customer service [a] | 0.52 | | 0 | 1 | 0.46 | | 0.60 | | * |
| Manufacturing [a] | 0.74 | | 0 | 1 | 0.73 | | 0.76 | | |
| Innovation cooperation with research organisations [a] | 0.45 | | 0 | 1 | 0.26 | | 0.69 | | * |
| Other types of cooperation [a] | 0.53 | | 0 | 1 | 0.47 | | 0.60 | | * |
| Qualification level of employees | 11.19 | 12.85 | 0.00 | 90.00 | 7.86 | 9.06 | 15.58 | 15.54 | * |
| Firm size (log) | 4.04 | 0.71 | 2.30 | 5.52 | 3.95 | 0.66 | 4.16 | 0.75 | * |
| Low-tech sector [a] | 0.63 | | 0 | 1 | 0.73 | | 0.51 | | * |
| Producer of finished goods [a] | 0.60 | | 0 | 1 | 0.61 | | 0.59 | | |
| Labour intensity | 60.01 | 20.92 | 0 | 100 | 63.10 | 20.95 | 55.95 | 20.21 | * |

Source: German Manufacturing Survey 2015, Fraunhofer ISI; own calculations
Notes. a. Dummy variables
* = A statistically significant difference between the samples of non-R&D and R&D SMEs based on the Student's t-test on the difference between means (at the .01 level).

# APPENDIX 4

Table 3.7: Simple correlations among the independent variables (Non-R&D SMEs N=472)

| | *Variables* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Engineering [a] | 1 | | | | | | | | |
| 2 | Customer service [a] | .071 | 1 | | | | | | | |
| 3 | Manufacturing [a] | .155** | .181** | 1 | | | | | | |
| 4 | Innovation cooperation with research organisations [a] | .266** | .053 | .080 | 1 | | | | | |
| 5 | Other types of cooperation [a] | .082 | .093* | .060 | .165** | 1 | | | | |
| 6 | Qualification level of employees | .188** | .036 | -.040 | .211** | .073 | 1 | | | |
| 7 | Firm size (log) | .254** | .001 | .149** | .288** | .058 | .076 | 1 | | |
| 8 | Low-tech sector [a] | -.266** | -.121** | -.101* | -.145** | -.012 | -.316** | -.105* | 1 | |
| 9 | Producer of finished goods [a] | .002 | .246** | .022 | -.063 | .059 | -.001 | -.096* | .057 | 1 |
| 10 | Labour intensity | -.064 | -.151** | .003 | -.057 | -.100* | -.356** | -.030 | .232** | -.177** |

Source: German Manufacturing Survey 2015, Fraunhofer ISI; own calculations
Notes. a. Dummy variables
** = Correlation is significant at the 0.01 level (2-tailed).
* = Correlation is significant at the 0.05 level (2-tailed).

# CHAPTER 4

## An integrated conceptual framework for analysing heterogeneous configurations of absorptive capacity in manufacturing firms

**Abstract:** Scholars of different disciplines widely agree that firms follow heterogeneous innovation patterns, meaning that different types of knowledge are relevant for their innovation activities. Given this fact, it is reasonable to assume that firms are also characterised by heterogeneous absorptive capacity patterns that fit their innovation behaviour. However, to date, research has not paid any attention to this potential heterogeneity in firms' absorptive capacity. The main objective of this paper is to explore the heterogeneity in firms' configurations of absorptive capacity. To reach this goal, we introduce a conceptual framework that integrates different constitutive elements on the individual and organisational level and dimensions of absorptive capacity taken from previous literature. We illustrate and apply the proposed framework based on three example firms from the German manufacturing industry, each following a distinct innovation strategy. Our empirical findings provide support for the heterogeneity assumption and allow the differences in the configurations of absorptive capacity to be linked to the firm's dominant innovation mode and strategic goals. Thus, by showing its potential to capture the heterogeneity of absorptive capacity in an empirical analysis, our framework can serve as a comprehensive basis for a more differentiated understanding of absorptive capacity and improve its measurement.

**Key words:** absorptive capacity; innovation patterns; heterogeneity; manufacturing firms; qualitative research

## 4.1 INTRODUCTION

Given today's increasing technological dynamics, the convergence of technologies, and discontinuities rooted in the digital transformation of sectors and industries, the knowledge and know-how required for innovation are increasingly located outside the firm. Therefore, the ability of a firm "…to recognize the value of new, external information, assimilate it, and apply it commercial ends", defined as the 'absorptive capacity' of a firm (AC hereafter) (Cohen and Levinthal, 1990) is likely to become a future core capability of competitively successful companies (Camisón and Forés, 2010).

Accordingly, much research has been done on the AC of firms in the past years to better understand its underlying processes and mechanisms (e.g. Easterby-Smith et al., 2008; Lane et al., 2006; Marabelli and Newell, 2014), process dimensions and their flows (e.g. Horvat et al., 2018; Todorova and Durisin, 2007; Zahra and George, 2002), its organisational (e.g. Fosfuri and Tribó, 2008; Jansen et al., 2005; Murovec and Prodan, 2009) and individual-level antecedents (e.g. Distel, 2017; Minbaeva et al., 2003; Schweisfurth and Raasch, 2018), as well as its effects on the firm's outcomes (e.g. Fabrizio, 2009; Tsai, 2001). However, despite the considerable number of conceptual and empirical studies, their findings provide rather fragmented insights, and the AC construct is criticised for remaining conceptually and methodologically underdeveloped (Lewin et al., 2011; Song et al., 2018; Volberda et al., 2010). In this study, we aim to address one of the major shortcomings severely hindering the further development of the AC concept, namely the lack of recognition of the heterogeneity in firms' AC patterns. Today, there is widespread consensus that firms differ in terms of their innovation patterns (e.g. Leiponen and Drejer, 2007; Nelson, 1991; Pavitt, 1984; Peneder, 2010), modes of learning and knowledge creation (e.g. Jensen et al., 2007; Lundvall and Johnson, 1994; Parrilli et al., 2020), as well as the internal and external knowledge sources relevant for their innovation activities (e.g. Fitjar and Rodríguez-Pose, 2013). In this context, it is surprising that firms' AC is still treated as a homogeneous, ideal-type capability that is likely to be found in similar shapes and configurations across different firms (Murovec and Prodan, 2009; Vera et al., 2011). Past research provides little insight into the role of strategy for AC (Lane et al., 2006) and, to our best knowledge, does not link the heterogeneity in firms' innovation behaviour to possible heterogeneity in firms' AC configurations. Therefore,

this current understanding of AC addresses only some particular, mainly R&D-based modes and patterns of innovation and is only partly applicable to innovation management literature, which has long recognised inter-firm heterogeneity.

This paper is therefore rooted in the basic premise that the different strategic orientations and innovation patterns of firms are likely to result in heterogeneous configurations of AC. The first empirical evidence to support this assumption was presented by Som et al. (2013), who analysed quantitative firm-level data from the German manufacturing industry. Based on their findings, the authors argue that firms relying on different types of internal resources and activities (R&D-based versus non-R&D-based) are still able to develop similar levels of AC, but they may use different underlying mechanisms to do so, i.e. their AC configuration varies. This AC configuration is likely to depend on the strategic relevance of targeted knowledge for a firm's competitive advantage. Additionally, based on qualitative insights from manufacturing firms, Horvat et al. (2018) also indicate that the AC configurations on the process level might differ between firms according to their individual competitive strategies and innovation behaviour.

This paper aims to develop this perspective further. Its main objective is to explore heterogeneous AC configurations of manufacturing firms in the context of different strategic orientations and heterogeneous innovation behaviour.

To achieve this research goal, we first build on the results from previous theoretical and empirical research on AC and develop a conceptual framework that integrates the key building blocks of a firm's AC on the individual and organisational level. This framework subsequently serves as the conceptual basis for empirically exploring different AC configurations of manufacturing firms. Following the criteria proposed by Whetten (1989) for developing a conceptual framework, we (a) identify and describe the key constitutive elements of a firm's AC in the existing literature, (b) describe and explain interactions between these elements, and (c) provide insights into correlations between the AC configuration and the firm's strategic orientation and innovation pattern. Second, by drawing on qualitative, multiple-case study data from three German manufacturing firms, we illustrate the proposed conceptual framework and explore the potential heterogeneity in the firms' individual AC configurations. Third,

based on the framework and the empirical insights, we discuss our contributions to the AC literature and make suggestions for academics, practitioners and policy makers on how to apply the results.

The paper makes a contribution to innovation management research and advances our understanding of AC by integrating different streams of literature, such as the process perspective (Zahra and George, 2002), research on the underlying organisational components of AC (Song et al., 2018), and the nascent microfoundation stream highlighting the role of individuals in the deployment of a firm's AC (e.g. Distel, 2017; Martinkenaite and Breunig, 2016; Sjodin et al., 2019). The proposed integrated AC framework provides a conceptual basis for both qualitative and quantitative analyses of heterogeneous AC configurations in manufacturing firms, as well as for further extensions and refinements of the AC theory. Such a framework would allow existing and future studies to be mapped at different levels of AC. Furthermore, an integrated conceptual AC framework provides the foundation to improve existing and develop new measurement concepts for different types of AC. Finally, managers and practitioners stand to benefit from a better understanding of how to configure a firm's AC and its constitutive elements, and how to link it to the firm's innovation strategy to create and maintain competitive advantages from exploiting external knowledge.

## 4.2 THEORETICAL BACKGROUND

Scholars of different disciplines agree that the competitive advantage of firms is rooted in their individual routines (Nelson, 1991; Nelson and Winter, 1982), the "strategic fit" between market characteristics and firm-specific bundles of valuable resources (Barney, 1991; Porter, 1996) and organisational core competencies (Prahalad and Hamel, 1990). The resulting heterogeneity of firms' strategic and innovation behaviour has been empirically underpinned by a large number of studies (e.g. Jong and Marsili, 2006; Leiponen and Drejer, 2007; Som, 2012). These studies also showed that firms following different innovation patterns differ in their degree of openness and rely on different external sources of knowledge (Jong and Marsili, 2006; Leiponen and Helfat, 2010; Som, 2012; Srholec and Verspagen, 2008). Accordingly, the characteristics of external knowledge, such as novelty, complexity, tacitness, similarity to internal knowledge base,

or degree of applicability (e.g. Lane et al., 2006; Lane and Lubatkin, 1998; Vega-Jurado et al., 2008), affect the rate at which knowledge can be absorbed, how and where it can be internally stored, and how easily it can be disseminated across the firm and applied (Argote et al., 2003). Thus, the nature of the targeted external knowledge makes different demands on a firm's internal capabilities, in particular, the level and internal organisation of the firm's absorptive capacity (Bogers and Lhuillery, 2011; Murovec and Prodan, 2009; Schmidt, 2010).

Given this consensus, it is surprising that most empirical studies treat AC as a general purpose, homogeneous construct (Song et al., 2018) and do not account for the potential heterogeneity in firms' AC patterns. Despite a number of re-conceptualisations and refinements (e.g. Lane et al., 2006; Lewin et al., 2011; Marabelli and Newell, 2014; Todorova and Durisin, 2007; Volberda et al., 2010; Zahra and George, 2002), a firm's AC continues to be considered as an ideal-type capability with similar patterns and configurations across different firms (Murovec and Prodan, 2009; Vera et al., 2011).

The only differentiation at firm level that has been taken into consideration so far is the realised level of AC: firms with a higher level of R&D investments are assumed to have higher AC (e.g. Mowery et al., 1996; Spithoven et al., 2011). In fact, by linking AC to a firm's formal R&D (e.g. de Jong, J. P.J. and Freel, 2010; Escribano et al., 2009; Grimpe and Sofka, 2009; Mowery et al., 1996; Tsai, 2001; Veugelers, 1997), the majority of studies examine it in the context of the R&D-based STI (Science, Technology and Innovation) mode of learning and innovation (Jensen et al., 2007) and prioritise explicit, technological knowledge (Lane et al., 2006; Robertson et al., 2012; Song et al., 2018). However, this mode of innovation is only one of several options that firms can build on. Firms also rely on other, complementary modes based on learning-by-doing, learning-by-using, learning-by-interacting, learning-by-producing, and learning-by-searching, which are tacit in nature (Jensen et al., 2007; Lundvall and Johnson, 1994; Parrilli et al., 2020) and which are likely to require different configurations of AC. Indeed, only a handful of studies distinguish between different types of AC, for instance, in terms of technological, scientific AC and market-oriented, industrial AC (e.g. Murovec and Prodan, 2009; Schmidt, 2010; Som et al., 2013; Vega-Jurado et al., 2008). These provide early

indications that the nature and strategic relevance of different external knowledge sources lead to different, heterogeneous configurations of firms' AC.

Building on evolutionary innovation literature (e.g. Nelson, 1991; Nelson and Winter, 1982), the resource-based view (e.g. Barney, 1991; Peteraf, 1993) and an emerging research stream of resource orchestration (e.g. Carnes et al., 2017; Sirmon et al., 2011), this paper argues that firms following different strategies and innovation patterns necessarily have to develop individual configurations of AC by orchestrating their valuable and heterogeneous innovation resources, in order to achieve a fit between environmental and organisational contingencies (Fainshmidt et al., 2019; Ritter and Gemünden, 2004; Zajac et al., 2000). First, the firm's strategy determines whether and to what extent it requires external knowledge for the desired innovation outcome and, if so, which knowledge is relevant, valuable and worth being absorbed (Lane et al., 2006). A firm's strategic orientation and targeted types of innovation shape the scope and direction of its knowledge search and define the criteria for assessing the business value of targeted knowledge (Martinkenaite and Breunig, 2016).

Additionally, it is reasonable to expect that the organisational resources firms can allocate to the AC process also vary depending on their strategy and innovation pattern. On the one hand, the configuration of AC is contingent upon the firm's internal resources: organisational structure, processes, competences and knowledge base that determine which knowledge is feasible to access and apply (Lane et al., 2006). On the other hand, the strategy sets the priority and determines which of the available innovation resources can be dedicated to building and deploying AC. Thus, if the targeted external knowledge is of high strategic relevance, the firm can overcome the constraint of resources (e.g. Som et al., 2013; West and Bogers, 2014), for example, by undertaking additional efforts and investing in the qualification of its employees (Weidner, 2020).

Putting these pieces together, we assume that different strategic orientations and innovation patterns of firms are likely to result in different, heterogeneous configurations of AC.

## 4.3 DEVELOPMENT OF CONCEPTUAL FRAMEWORK

To capture the heterogeneity in firms' AC configurations, we need to move beyond the fragmented findings of previous research and examine AC from a more comprehensive, integrated perspective by considering different dimensions, facets and levels. For this purpose, we build upon three streams in existing AC research: (i) the process perspective, (ii) the perspective of constitutive elements, and (iii) the perspective of AC microfoundations at the level of individuals. Each of these streams offers a distinct and valuable angle to look at firms' AC. The process perspective underlines the multidimensionality of AC and depicts its core functions. The constitutive elements perspective underscores the multifaceted nature of AC and shows that firms can proactively develop and enhance their AC. Finally, the microfoundation perspective stresses the role of individuals and highlights the multi-level character of AC.

Figure 4.1 illustrates the proposed conceptual framework. In the following sections, we describe the AC framework, its constitutive elements and their interrelations in more detail.

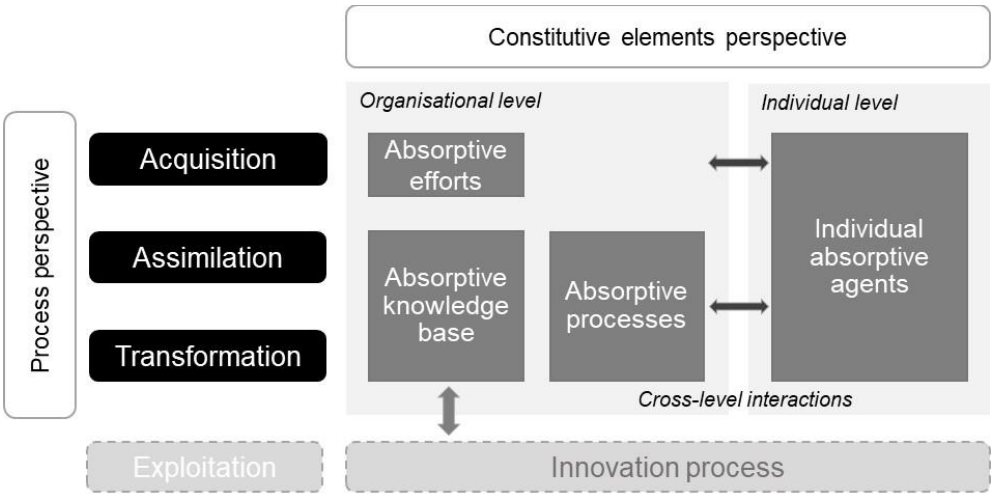


Figure 4.1: The integrated framework of AC
(own illustration)

***Process-based perspective***

The process-based perspective emphasises the dynamic nature of AC and describes it as a sequence of functions of recognising the value of new external knowledge, assimilating

it, and applying it to commercial ends (e.g.Easterby-Smith et al., 2008; Lane et al., 2006; Marabelli and Newell, 2014; Patterson and Ambrosini, 2015). In our framework, we adopt one of the most influential and widely cited re-conceptualisations of AC by Zahra and George (2002). They define a firm's AC as a dynamic capability that encompasses four distinct, but complementary dimensions: acquisition, assimilation, transformation and exploitation. In our framework, we excluded the exploitation dimension for two reasons. First, it causes a tautology problem by strongly overlapping with the knowledge outcome of AC (Song et al., 2018). Second, since exploitation routines belong to the operational level of a firm's innovation management, and are not exclusively related to AC, we suggest that the process of knowledge absorption ends up at the transformation phase (Horvat et al., 2018).

Activities underlying the phases of the AC process are generally characterised by the literature in terms of firm-specific and idiosyncratic organisational routines or practices (Lewin et al., 2011; Zahra and George, 2002) (see Table 4.2 for relevant examples).

***Constitutive elements perspective***

This perspective highlights the organisational context and considers the building blocks that firms rely on to build and deploy AC (e.g. Burcharth et al., 2015; Fosfuri and Tribó, 2008; Jansen et al., 2005; Schmidt, 2010; Volberda et al., 2010). These building blocks are transverse to the phases of the AC process. Depending on the manifestations and configurations of these building blocks, firms are able to manage their AC by making its single dimensions more effective. In our framework, we build on one of the most recent holistic categorisations by Song et al. (2018). Using a comprehensive conceptual distillation of previous theoretical and empirical studies of AC, they distinguish three key organisational-level pillars of AC, namely absorptive efforts, absorptive knowledge base and absorptive processes. These pillars are interrelated, but conceptually distinct. Each has a particular emphasis, and fulfils a particular function in the firm's AC process.

*Absorptive efforts*

Absorptive efforts represent the knowledge- and capability-building investments made by a firm to facilitate the search for and recognition of valuable, relevant external knowledge (Song et al., 2018). According to their underlying "radar" function, absorptive efforts are primarily relevant for the acquisition dimension of a firm's AC (Zahra and George, 2002). As underscored in the seminal work by Cohen and Levinthal (1990), exposure to diverse external sources is not sufficient to successfully absorb external knowledge; "intensity of effort is critical" (p. 131). Following the work of Cohen and Levinthal, the majority of subsequent studies focused on R&D efforts (e.g. de Jong, J. P.J. and Freel, 2010; Escribano et al., 2009; Grimpe and Sofka, 2009; Mowery et al., 1996; Tsai, 2001; Veugelers, 1997), although some researchers criticised this excessive R&D focus. They drew attention to the internal efforts that go above and beyond formal R&D, such as investments in learning, education and training programs (Hervas-Oliver et al., 2012; van Wijk et al., 2011) and the hiring of qualified personnel with relevant skills and competences (e.g. Schmidt, 2010).

*Absorptive knowledge base*

The second constitutive element is the absorptive knowledge base that Song et al. (2018) describe as "the accumulated stock of knowledge held by the firm that facilitates understanding, recombining, and transforming of external knowledge". In terms of the dimensions in Zahra and George (2002), the absorptive knowledge base is predominantly needed for the assimilation and transformation dimensions of AC. This constitutive element originates from the notion of Cohen and Levinthal (1990) that AC is largely a function of the level of prior related knowledge. Many subsequent studies promoted this notion and underlined the importance of prior related knowledge for the development of AC (e.g. Burcharth et al., 2015; Lewin et al., 2011; Van Den Bosch et al., 1999; Vega-Jurado et al., 2008; Zahra and George, 2002). In contrast to absorptive efforts, which are rather future-oriented, the absorptive knowledge base represents past cumulative experience and tends to be developed path-dependently (Song et al., 2018). The accumulated organisational knowledge base of the firm enables key individuals to analyse external knowledge, come to a shared understanding, and interpret and assess the value

of this knowledge in the context of the organisation. Moreover, existing knowledge-processing routines, which underlie the firm's knowledge stock, help to integrate the acquired knowledge by recombining and transforming it within existing structures, systems and processes (Song et al., 2018). On the other hand, individual actions contribute to the consequent changes in the absorptive knowledge base by creating new pieces of organisational knowledge and modifying existing systems, structures and processes.

*Absorptive processes*

The final constitutive element proposed by Song et al. (2018) are absorptive processes, which are defined as internal procedures and practices that facilitate the sharing and dissemination of external knowledge within the firm. Thereby, absorptive processes underscore the notion of Cohen and Levinthal (1990) that a firm's AC depends on "the links across a mosaic of individual capabilities". Their primary function is to gather individual knowledge, convert it into organisational-level knowledge, and then transmit it to the various business units and entities within an organisation (Lane et al., 2006). Hence, absorptive processes play a major role during the assimilation and transformation phases of AC (Zahra and George, 2002). In addition to conversion and transmission by means of formalisation mechanisms, absorptive processes also play an important role in storing and retrieving organisational knowledge (Jansen et al., 2005).

***Microfoundation movement and individual absorptive agents***

The third stream of AC literature considered in our framework is the emerging microfoundation movement in AC research (e.g. Distel, 2017; Enkel et al., 2017; Lowik et al., 2017; Sjodin et al., 2019). This stream of research underlines that individual action and individual agency are of great importance for the successful development and sustainment of AC (Lewin et al., 2011; Sjodin et al., 2019; Volberda et al., 2010). Although the crucial role played by the organisational aspects of AC is undisputed, from a practical point of view, it is the firm's individuals who ultimately drive the process of knowledge absorption (Lane et al., 2006). Therefore, we extend the organisational components suggested by Song et al. (2018) to include individuals as a further pillar of a firm's AC throughout all its phases.

Traditionally, research has considered the role of individuals to be central during the acquisition phase, which is highly cognitive and associated with individuals' intuition and interpretation (Crossan et al., 1999; Sun and Anderson, 2010). This phase rests on organisational roles such as gatekeepers and boundary spanners, who act as the points of entry for new external knowledge (Cohen and Levinthal, 1990; van Wijk et al., 2011). Their mental models, motivation, abilities and experience influence the locus and effectiveness of knowledge search (Crossan et al., 1999; Minbaeva et al., 2003; Sjodin et al., 2019; Sun and Anderson, 2010).

As the AC process progresses, the focus of analysis in the majority of studies shifts from the level of individuals to the firm (Sun and Anderson, 2010). Empirical findings on the role of individuals and individual-level actions beyond the acquisition phase are quite limited. First, the boundary spanners and gatekeepers who initially recognised the relevant external knowledge are still involved at the subsequent phases of the AC process (Sjodin et al., 2019). These individuals share the results of the acquisition phase with the wider group by corroborating the knowledge value (Sjodin et al., 2019; Ter Wal et al., 2017). To gain the group's acceptance, they have to demonstrate the business potential of the acquired knowledge in the firm's context and to ensure legitimacy allowing the assimilation to occur (Sjodin et al., 2019). Second, to ensure the successful integration of contextualised knowledge and its exploitation, key individuals champion new knowledge by lobbying for support, securing resources and handling organisational resistance (Lewin et al., 2011; Sjodin et al., 2019). Accordingly, individuals rely strongly on support from credible high-status individuals, such as formal and informal leaders, "shepherds", "idea champions", "change agents" and "power and process promoters" (Gemünden et al., 2007; Jones, 2006; Lewin et al., 2011; Sjodin et al., 2019; Ter Wal et al., 2017).

### *Cross-level interactions*

Finally, we extend our framework by vertically integrating individuals and organisational components. In fact, although past research conceptually acknowledged that AC is a multi-level construct (e.g. Lane et al., 2006; van Wijk et al., 2011), the multi-levelness of AC is still theoretically underdeveloped (Marabelli and Newell, 2014; Volberda et al.,

2010) and only a few studies have addressed it empirically and examine individual-organisation interactions (e.g. Distel, 2017; Sjodin et al., 2019; Yao and Chang, 2017). Marabelli and Newell (2014) and Martinkenaite and Breunig (2016) argue that developing a solid theory around the multi-level aspects of AC by considering individual-organisation interactions could further advance the theoretical development of the concept. We not only integrate individuals as another pillar of the internal organisation of AC (see previous section), but also add cross-level interaction between the individuals and organisational elements for each phase of the AC process to our framework (see Figure 4.1). By doing so, we circumvent the problematic idea that AC emerges in individuals and spreads to the collective (cf. Marabelli and Newell, 2014), and instead consider AC as the result of dynamic interplay between individuals and the organisation throughout the entire AC process. Accordingly, each phase of AC encompasses both individual absorptive agents and organisational-level components.

## 4.4 RESEARCH DESIGN AND METHODOLOGY

### *Case selection*

The paper adopts a qualitative, multiple case study approach (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Yin, 2009). This approach allows us (a) to underpin the integrative framework of AC developed in the theoretical part by empirically illustrating single constitutive elements and the interactions between them, as well as (b) to explore the heterogeneity of AC configurations in a comparative setting. For the empirical analysis, we selected three firms from the German manufacturing industry with fewer than 500 employees that differ in terms of their innovation behaviour and their structural characteristics, such as size, sector affiliation, and position in the value chain (see Table 4.1). Company *Alpha* is a furniture manufacturer of swivel chairs. Company *Beta* is a supplier of tailor-made, customer-specific, aluminium technical extruded parts and assemblies for the automotive industry. Company *Gamma* is a manufacturer of electric heating components for different application fields.

To provide a meaningful comparison between these firms regarding the configuration of their AC, the selected cases fulfil three criteria. Firstly, all of the selected

cases show a substantial degree of openness in their innovation behaviour requiring a minimal level of AC. They all display a minimum level of AC, as they are obviously able to identify and access relevant technological external knowledge as well as integrate and use this successfully to implement product and process innovations. Secondly, they all source a wide range of different formal and tacit knowledge types, including technological knowledge and practical know-how provided by suppliers, customers, end-users, and knowledge originating from collaborations with universities and research organisations. Thirdly, they do not perform formal in-house R&D. The reason for this criterion is that our framework is built on insights from the mainstream, R&D-driven AC literature, and non-R&D-performing cases representing an opposite extreme to large R&D firms (cf. Moilanen et al., 2014) can be considered a more challenging empirical setting to test the framework. Their AC is assumed to be less institutionalised and thus configurations of constitutive AC elements are harder to disentangle by empirical analysis.

Given the overall aim of this paper to explore heterogeneous AC configurations based on the assumption that a firm's innovation strategy is likely to shape its AC configuration, we selected firms that exhibit different innovation patterns. The managing directors assigned their firm to one of the presented innovation patterns. As all three cases do not perform formal R&D, we relied on the classification of innovation patterns of non-R&D-performing firms proposed by Som (2012) for the German manufacturing industry. Accordingly, company *Alpha* can be characterised as an (occasional) B2C product developer (cf. Som, 2012). The firm has the strong innovation capacity needed to develop new products. It relies on internal creativity, design and marketing to provide individual product-service bundles to each of its customer groups and on innovative manufacturing processes to ensure production speed and high flexibility. Company *Beta* complies with the pattern of a customer-driven technical process specialist (cf. Som, 2012). It shows outstanding ability to engineer and perform highly specific and complex projects to meet the technical requirements and needs of customers in terms of quality, reliability and delivery time. Finally, company *Gamma* can be described as a volume flexible specialised supplier (cf. Som, 2012). The firm is good at adapting existing standardised products to new fields of application and developing customer-tailored parts and components.

Customers are the main driving force behind the extensive technical changes to products, and *Gamma* is able to implement these changes successfully. (See Table 4.1 for further details.)

Table 4.1: Case study overview

| Characteristics/Case | Case *Alpha* | Case *Beta* | Case *Gamma* |
|---|---|---|---|
| Number of employees [a] | 450 | 200 | 55 |
| Manufacturing sector | Manufacture of furniture | Metal products | Electrical equipment |
| Product | Swivel chairs | Technical extruded aluminium parts and assemblies | Customer-tailored electric heating components |
| Position in the value chain | Producer of finished goods for a range of customer groups | Supplier of parts/components for the automotive industry | Supplier of parts/components for the plastics sector and general mechanical engineering |
| Innovation pattern (cf. Som 2012) | Manufacturer of consumer goods with occasional product development | Customer-driven technical process specialist | Volume flexible specialised supplier |
| Major competitive factors | Innovative products and product design<br>Short delivery times and short time to market<br>Quality | Product customization<br>Technical process innovation and engineering<br>Quality-price ratio | Organisational innovation<br>Quality<br>Short delivery times<br>Product customization |
| Main challenges | Shortage of qualified staff<br>Increasing product complexity<br>Automation of production and logistics / Higher efficiency of production processes<br>Sustainability of supply chain | Digital transformation ("Industry 4.0")<br>Strict regulations and high standards in terms of quality and accuracy<br>Cost efficiency<br>Mature market / Need for development of new business areas | Shortage of qualified staff<br>Higher efficiency of production processes<br>Increasing market competition / Need for sustainable development<br>Finding new application fields for core competences |
| Examples of absorption triggers | Identification of a solution to a technical problem (in the context of product and process innovations) | | |
| | - Integration of automated guided vehicles (AGV)<br>- Usage of materials new to the firm (aluminium, carbon) | - Usage of hybrid materials in product development<br>- Identification of new lubricants, new tool coating with better characteristics<br>- Integration of machinery with new functionality | - Potential application of industrial collaborative robots to automate monotone, simple tasks in the production process<br>- Integration of laser inscription |
| Type of relevant knowledge | Search for technological knowledge with a high tacit component (experience of partners with the integration and exploitation of the technology, solving potential problems). Primary data sources are suppliers, universities and customers | | |
| Number of primary semi-structured interviews | 1 interview with managing director<br>(1 hour) | 2 interviews with managing directors<br>1 interview with Head of Technical Sales<br>1 interview with Head of Construction and Tool Shop<br>(5 hours in total) | 2 interviews with managing directors<br>(2.5 hours in total) |

Notes. a. The numbers refer to the time of the data analysis

***Data collection***

To examine the configurations of AC across the selected firms, we conducted in-depth (ethnographic) case studies as part of a three-year research project funded by the German Ministry of Education and Research. To ensure higher construct validity and to gain complementary insights, we used several data collection techniques (data triangulation) (Gibbert et al., 2008; Yin, 2009).

As the primary data source, we conducted semi-structured, face-to-face interviews with managing directors of the selected firms (Rowley, 2012). The conducted interviews were structured around an innovation project or a process of innovation development in which a firm required external knowledge impulses for problem-solving. In this way, AC was discussed in the interviews not as a theoretical concept but rather in terms of its role and functions in the innovation process. Each interview lasted between 60 and 90 minutes. The interviews were recorded and subsequently transcribed with the permission of the interviewees.

Then, the initial data were extended by several follow-up interviews and informal conversations with employees actively involved in innovation processes. These conversations took the form of both problem-focused and narrative interviews. They provided additional meaningful insights, which played a particularly important role in explaining ambiguities after the semi-structured interviews. In this way, we were able to capture the researched phenomena as comprehensively as possible.

Further, to complement our primary data sources, we relied on secondary data, such as reports, presentations, websites, and project materials. In addition, by being members of the project team over the three years of the research project, we were able to observe the firms' specific organisational practices, e.g. communication and interactions among employees in innovation processes. These secondary data sources allowed us to double-check the subjective assessments made in the interviews using more objective fact-based data.

***Data analysis***

We conducted the qualitative data analysis following the approach adapted from Jantunen et al. (2012) who explored heterogeneity of dynamic capabilities in a comparative setting. To start with, we analysed the secondary data aiming at understanding the context in which the firms operate, their competitive strategies, and innovation behaviour. We also looked at the context of knowledge absorption: the triggers activating the AC process, the typical problem situations which require external inputs, and the main external sources.

Then we coded deductively our primary data using the developed conceptual framework as a coding frame (see Figure 4.1 and Table 4.2). As coding categories, we relied on the examples of related organisational practices and various manifestations of the key constitutive elements derived from previous literature. First, based on the examples of related practices and routines (the second column in Table 4.2) we were able to identify the phases of the AC process in our empirical material. Then, we assigned various manifestations of organisational mechanisms (the firth column in Table 4.2) to the key constitutive elements by considering their function in the AC process (the third column in Table 4.2). Finally, we linked the key constitutive elements to the phases of the AC process. After this round, we were able to describe single constitutive elements and the interactions between them along the AC process for each case.

The goal of the next analytical step was the cross-case comparison of the empirical case-specific manifestations of the constitutive elements of AC (see Eisenhardt, 1989; Miles et al., 2014). We examined the data on each constitutive element, individually as well as in combination, and identified similarities and differences between cases. This round resulted in the detailed description of similarities and firm-specific patterns in the configurations of the single phases and the entire AC process.

In the final step, we analysed connections between firm-specific AC configurations and the firm's context, strategic orientation and innovation patterns in order to better understand the firm-specific patterns and hence the differences between cases.

Table 4.2: Coding frame for the underlying components of absorptive capacity

| Phases of AC process | Examples of related organisational practices | Function | Constitutive element | Examples of related manifestations |
|---|---|---|---|---|
| Acquisition | • searching for new relevant knowledge (through scouting/search activities)<br>• learning from partners (incl. boundary spanning, cooperation, etc.)<br>• individual valuation of knowledge relevance (preliminary assessment of its potential in terms of value, novelty and technological feasibility) | radar | individuals | Boundary spanners and gatekeepers |
| | | | absorptive efforts | • R&D efforts<br>• Training and learning (e.g. job rotation, , on-the-job training, external trainings and qualification programs)<br>• Hiring<br>• Working conditions (e.g. autonomy, high flexibility)<br>• Incentive structures<br>• Facilitating innovation culture |
| Assimilation & Transformation | (1) Assimilation practices<br>• Sharing of gathered individual knowledge with the group through interpersonal communications<br>• Collective interpretation and valuation of new acquired ideas in the context of the firm (contextualisation)<br>• Selection of most promising ideas to proceed further (corroborating business value)<br>• Channelling and shepherding the selected ideas to the next phase of the AC process by relying on the support of high-status individuals<br>(2) Transformation practices<br>• Processing of knowledge<br>• Integration of new knowledge into existing knowledge base<br>• Knowledge storage for further exploitation | processor | individuals | Boundary spanners, shepherds, change agents, etc. |
| | | | absorptive knowledge base | • Collective knowledge shared among the individuals and embedded in structures, systems, documentations, established routines and procedures (e.g. knowledge-processing routines; knowledge management systems) |
| | (3) Dissemination practices<br>Knowledge sharing and dissemination of new knowledge across the organisation to key individuals involved in the AC process at the latter stages | converter and transmitter | absorptive processes | • Social integration mechanisms<br>• Combinative capabilities (e.g. quality circles, cross-functional interfaces, participation in decision-making, job rotation, formalisation, connectedness)<br>• Positioning of key individuals<br>• Teams' composition |
| Zahra and George, 2002 | e.g. Duchek, 2015a; Horvat et al., 2018; Zahra and George, 2002 | Song et al., 2018 | | e.g. Burcharth et al., 2015; Jansen et al., 2005; Martinkenaite and Breunig, 2016; Minbaeva et al., 2003; Van Den Bosch et al., 1999; Zahra and George, 2002 |

## 4.5 RESULTS

### *Individual case analysis*

The following section portrays the AC configurations of the individual cases. The focus here is on presenting the main distinctive features of each case, whereas the full, systematic description of the key elements in terms of their underlying manifestations can be found in Tables 4.4 and 4.5 in the Appendix.

*Company Alpha*

The acquisition phase of Company *Alpha* is quite centralised. It relies upon three high-status individuals: the CEO, head of production and head of the purchasing department. The CEO is the key boundary spanner for research-based, scientific knowledge, while the head of production and head of purchasing are mainly responsible for knowledge from suppliers and industry representatives. Due to their strong knowledge base, experience and access to wide networks, these key boundary spanners also make individual decisions regarding the potential and business value of the relevant external knowledge. Accordingly, middle managers and other employees only come into contact with external knowledge at later stages of the absorption process. Consequently, as stated by the CEO, the main challenge is to share the acquired knowledge and anchor it in organisational structures.

> "Then of course I have to provide the decentralized entities with knowledge" (Case *Alpha*, Managing director)

Hence, the company needs appropriate communication mechanisms to pass on knowledge from the three key individuals and disseminate it throughout the organisation. The firm relies on numerous agile meeting structures and intensive communication mechanisms involving diverse groups of employees. In this constellation, the role of top manager is central for AC. He is the key boundary spanner during acquisition and acts as an idea shepherd at subsequent stages.

Besides communication mechanisms, the company consciously dedicates time and funds to developing strategically important competences of employees who process

the selected ideas and carry them through the transformation phase of the AC process (e.g. employees of IT department, technical leads, and engineers).

> "We had no knowledge in this field, so we sent our people on training. And today, they are probably not on a par with manufacturers, but they are quite close. So they can formulate clear requirements and set the specifications. Then, of course, we refine these requirements together with the supplier, but we formulate the basic idea ourselves. In other words, we no longer need any consulting structures here." (Case *Alpha*, Managing director)

Production workers are not actively involved in the AC process, but they are the ones who apply the newly acquired and integrated knowledge in practice. To keep up-to-date with respect to new digital technologies, production workers should regularly attend external training and internal qualification measures, such as job rotation or train-the-colleague concepts. These practices aim at enhancing their competence level and their motivation to accept new technologies.

*Company Beta*

In company *Beta*, the acquisition phase is less centralised than in company *Alpha*, but still concentrated in the hands of a relatively small group of engineers and top managers with a strong technical background and experience. Engineers combine (a) customer requirements, (b) external knowledge impulses from diverse suppliers and research partners and (c) internal expertise and process know-how and then pass on the resulting information to other internal knowledge carriers. Due to their qualification and rich experience working with academia and R&D-intensive firms, engineers are able to learn from diverse partners and are crucial to the process of integrating the acquired knowledge due to their good overview of strategic objectives and internal business processes.

*Beta* differs significantly from *Alpha* as the key boundary spanners here – engineers – not only acquire new knowledge, but also accompany the assimilation and transformation phases. Regarding the potential business value of external knowledge and selecting the most promising technological solution, we observed a mix of individual and collective decisions in *Beta* depending on the complexity of the problem and level of financial investments needed. Either the engineers make individual decisions by themselves or they involve experts from the production department to test the technological feasibility and robustness of a solution, or even integrate external partners (customers, suppliers or research laboratories):

> "The assessment takes place depending on how big or small the innovation is. This risk assessment is used to decide whether production trials should be carried out first to prove it." (Case *Beta*, Managing director 2)

> "You can actually bring both tool manufacturers and machine manufacturers to the table and say: how would you solve this? That is the external knowledge that you then bring into the discussion." (Case *Beta*, Managing director 1)

Considering the key role of engineers throughout the entire AC process, the firm does not need to disseminate the knowledge broadly across the firm (as is the case in firm *Alpha*), but rather manage the conversion of theoretical knowledge into practical, tacit knowledge understandable to production workers. Therefore, the emphasis is not on intensive communication practices, but on the enabling structure of internal boundary spanners. In this vein, the firm introduced the position of "process developers", who are production workers with a master qualification and expertise about the manufacturing process and machinery. The integration of process developers at the early stages of the AC process raises the acceptance of the new technology and provides these employees with the knowledge needed for fast and efficient application. During the transformation phase, process developers engineer a new or modify the existing production process by integrating newly acquired technologies or machinery. In doing so, they "translate" the knowledge provided by engineers into the practical, tacit knowledge understandable to the rest of the production staff (e.g. machine setters and operators).

> "They play a very important role for us. They are the link between the engineering heads and the master craftsmen in the workshop." (Case *Beta*, Managing director 2)

*Company Gamma*

In company *Gamma*, the AC process starts with decentralised acquisition. The firm has deliberately created a cross-functional "Team Technology" that functions transverse to project and department structures and is primarily responsible for the search, acquisition and assimilation of relevant external impulses. The team comprises eight people, including both managing directors and employees with a strong technical background from the marketing, purchasing, production, and quality management departments. Beyond their operative tasks, team members are encouraged to be aware of new technological opportunities, and share new impulses with the team. High knowledge diversity resulting from the variety in the education, work skills and life experiences of

the team members enables a broad acquisition of knowledge from a wide range of sources, including more distant knowledge domains.

This decentralised architecture is built upon two pillars. First, it relies heavily on communication mechanisms, including formal and informal practices. However, in contrast to *Alpha*, the primary objective of such mechanisms in *Gamma* is not to disseminate the acquired and pre-selected knowledge for further processing, but to collect interesting ideas, and share and discuss them with the team members in order to make a collective decision regarding their follow-up. The diverse functional background of the team members means the technological feasibility and business value of the ideas can be evaluated from different angles. Furthermore, the cross-functional character of the team allows the effective spread of relevant information across different departments. The members of Team Technology assume the role of internal boundary spanners here between the team and their functional area.

Second, company *Gamma* has an open innovation culture and a high tolerance for failure. In this aspect, it is clearly different to company *Beta*, which declares rather low failure tolerance, probably due to the strong regulations and high quality standards in the automotive industry where *Beta* operates.

> "... just set up the antennas, be open to new ideas and who knows, maybe at some point we will be the first company able to produce a heating system for a specific application fully automatically, which is unthinkable at the moment." (Case *Gamma*, Managing director 1)

The managing directors of *Gamma* are also actively involved in the process of knowledge absorption. However, in contrast to *Alpha*, *Gamma*'s CEOs are not the major driver of AC, but rather one of several. Their main function is to create the opportunities and conditions for the key employees involved in the AC process.

### *Cross-case analysis and relationship between AC configurations, firm strategy and innovation behaviour*

The findings from the explorative analysis of all three cases show both commonalities and differences between the firms' AC configurations. In terms of commonalities, all three companies rely on individuals with a high degree of autonomy, flexibility and opportunities. For instance, company *Alpha* relies on high-status individuals, who have power, a high degree of autonomy and opportunities to access a wide range of external

sources due to their hierarchical position. In companies *Beta* and *Gamma*, the management grant a high degree of autonomy and flexibility in decision-making to middle managers and employees with a strong technical background. Further, boundary spanners in all three cases have an overview of their firm's strategic orientation and business context and can therefore evaluate which knowledge is most valuable to the firm and has the potential for future developments. While in companies *Alpha* and *Beta,* the key individuals responsible for acquisition are able to assess the business value of identified external impulses due to their functionality, Company *Gamma* makes sure their key boundary spanners are given an overview of the firm's priorities, current activities and problems to be solved.

On the other hand, the findings also highlight the differences in the firms' AC configurations (see Table 4.3) that can be traced back to their innovation behaviour and firm-specific organisational contexts described in Table 4.1. Firstly, the innovation pattern in *Alpha* relies on the fast and flexible manufacturing of swivel chairs for consumer markets. Accordingly, its AC configuration shows the dominant role of individual boundary spanners in the acquisition phase (top management), who are able to make fast decisions and, due to their high status, ensure the strategic relevance and business value of externally acquired knowledge. The relevance of "speed" here is reflected at the organisational level by a lower degree of formalisation and agile meeting structures. Indeed, assimilation and transformation follow an agile and decentralised approach involving a wide range of individuals making decisions about implementation, thereby driving the dissemination of newly acquired external knowledge within the organisation.

Secondly, case *Beta* follows an innovation pattern with the strongest technological orientation compared to the other two cases. To develop innovative solutions for their large automotive customers in the absence of formal R&D, this firm relies on a clever combination of externally acquired technological knowledge and practical, experience-based internal expertise of engineers, technicians and other production workers. This is reflected in the firm's AC configuration. First, due to the high knowledge intensity and strategic relevance of external knowledge for innovation success, the AC process is integrated into the business processes and has become part of employees' daily routines.

Second, engineers play a central role throughout the entire AC process, because they are the ones able to process the complex knowledge. The firm's top management values their intrinsic motivation to search for new external impulses and drive the innovation process:

> "It can only work if you constantly strive to improve the competences and qualifications of the employees involved. It is important that they develop further, not as a guided process, but rather that everyone is constantly aware of the developments and trends in their area of responsibility." (Case *Beta*, Managing director 2)

Table 4.3: Firm-specific characteristics of AC in the analysed cases

| | Criteria | Case *Alpha* | Case *Beta* | Case *Gamma* |
|---|---|---|---|---|
| Acquisition | Points of entry | Centralised in the hands of three high-status individuals | Concentrated in the hands of engineers | Decentralised acquisition |
| | Role of top management | The key boundary spanner | Some of the few key boundary spanners | Some of several boundary spanners |
| | Key enabling factor | The high status and possibilities of boundary spanners | Maintaining the high motivation and autonomy of key boundary spanners | Open innovation culture |
| Assimilation and Transformation | Decision-making regarding the most promising external impulses | Individual-level decisions by boundary spanners | Mix of individual and collective decisions, depending on the complexity of problem and the amount of investment needed | Collective decisions by "Team Technology" |
| | Role of top management | Idea shepherd | Technical consultants<br>Decision-makers where a solution is needed at a strategic level | Idea shepherds<br>Sparring partners |
| | Key enabling mechanisms | Diverse agile meeting structures to disseminate knowledge and champion the selected ideas | Process developers as internal boundary spanners | Cross-functional meetings of Team Technology (enabling structure) |
| | Dedicated process | Acquisition of external knowledge (search, access, evaluation) is considered a separate task; afterwards, the latter stages of the AC process are integrated into the daily operations of the business process. | All activities related to the AC process are integrated into the business processes. They are part of employees' daily activities. | Acquisition and assimilation of external knowledge take place in parallel to ongoing innovation / business process. |
| | Degree of formalisation | Less formalised approach with stronger focus on face-to-face dissemination of valuable insights related to the process innovations | Balanced approach. While the insights at the stage of modelling, simulation and engineering are well documented, insights gained on the production side (practical in nature) are mainly not documented in written form. | Formalised approach with focus on detailed documentation of gained insights, lessons learned, etc. |

Moreover, the firm integrates technicians, so-called "process developers", for knowledge assimilation and transformation because of their manufacturing expertise, and their position as internal boundary spanners who transfer knowledge from engineering to

the rest of manufacturing. This incorporates production workers, who are another crucial source of innovation impulses in this firm, into the AC process. The combination of externally acquired formalised knowledge, internal engineering expertise and practical know-how in the innovation process is reflected in the degree of formalisation in the AC process. The insights at the stage of modelling, simulation, and engineering are well documented. In turn, most of the know-how gained on the shop floor is not documented in a written form, as documenting this kind of knowledge is quite challenging and not very effective.

Thirdly, company *Gamma* is a specialised supplier and its innovation pattern is characterised by incremental product innovation and a strong focus on efficiency and flexibility. The company has established a layered organisational structure, which means that every customer has its "own" dedicated team composed of persons from engineering, production, sales, and marketing. This cross-functional structure is reflected in the cross-functional AC configuration. In contrast to the two other cases, acquisition activities are not concentrated on a few individuals, but broadly distributed across different functional layers of the firm. This is underpinned by collective decision-making led by Team Technology. To ensure smooth knowledge assimilation and transformation across the functional layers, the AC process is highly formalised with detailed documentation of insights gained, and lessons learned. Such a cross-functional structure as the foundation for AC combined with high flexibility in terms of decision-making and short communication paths enables the company to respond quickly and comprehensively to customer needs, and thus maintain a major competitive advantage. In contrast to *Beta*, the AC process in *Gamma* is a separate and well-defined process (at least in the acquisition and assimilation phases) that takes place in parallel to the ongoing business process, even if both are closely interconnected.

Another interesting difference in the analysed firms relates to the extent to which the AC process can be distinguished from the regular business processes. In *Beta*, all activities conceptually related to AC occur during daily operations as an organic part of the business processes. In the other two cases, AC-related activities are defined as separate tasks with dedicated time, resources and enabling structures, especially at the beginning of the AC process. The further the AC process progresses, the more AC-related

activities fuse with daily operations as part of business processes. Such differences in the "degree of integration" between the firms might be linked to the nature of their knowledge search approach. Firm *Beta* has a very pragmatic, problem-driven or task-specific search approach, and the process of knowledge absorption is organically integrated into the operations related to fulfilling these tasks, whereas firms *Alpha* and *Gamma* follow more generic approaches that are rather detached from daily operations.

## 4.6. CONCLUDING DISCUSSION AND IMPLICATIONS

Building on a large number of empirical innovation studies (e.g. Jong and Marsili, 2006; Leiponen and Drejer, 2007; Peneder, 2010; Som, 2012), the key premise of this paper was that firms differ in their individual AC configurations according to their strategic orientation and innovation behaviour. Different types of firms' innovation behaviour are reflected in the individual use and specific relevance of different internal and external knowledge sources (e.g. Fitjar and Rodríguez-Pose, 2013). Based on these insights from the literature on firms' innovation behaviour, the paper subsequently argued that it is plausible to assume that firms' AC is likely to differ according to their different types or modes of innovation behaviour. In other words, the way firms configure their AC reflects their strategy and innovation behaviour. However, to the best of our knowledge, existing studies treat a firm's AC as a homogeneous, ideal-type capability and do not account for potential heterogeneity in AC configurations associated with the heterogeneity in firms' innovation behaviour.

To account for and explore heterogeneous configurations of AC, we first proposed a conceptual AC framework that integrates the different constitutive elements and dimensions of heterogeneous AC configurations in manufacturing firms taken from previous literature. By building on renowned AC studies, the proposed framework sheds light on the different process stages (Zahra and George, 2002) and key constitutive components of firms' AC on an organisational (Song et al., 2018) and individual level (e.g. Distel, 2017; Sjodin et al., 2019), and includes vertical individual-organisation interaction (Marabelli and Newell, 2014; Martinkenaite and Breunig, 2016). To "test" the proposed conceptual framework, we selected three exemplary cases of manufacturing firms, each representing a different type of innovation pattern (according to the typology

by Som (2012)), and explored whether and to what extent the firms' AC configurations differ according to their type of innovation behaviour.

***Reconsidering the proposed framework***

The empirical analysis revealed that the proposed integrative framework of firms' AC provided a valid and useful basis for comprehensive operationalisation and analysis of different, firm-specific configurations of AC. First, the findings demonstrate that, besides vertical interactions, horizontal interactions between the organisational elements along the AC process are also an important pillar for firms' AC. Both vertical and horizontal interactions underscore the dynamic nature of the AC construct (cf. Zahra and George, 2002). The firm can purposefully re-adjust the configuration of its AC in order to improve the fit with certain strategically relevant stocks of external knowledge (e.g. a specific customer group, technology community). These adjustments can be achieved by means of (a) absorptive efforts that allow changes in the knowledge bases of key individuals, particularly those at the interface to the external environment; and (b) absorptive processes that allow changes in underlying structures, processes and procedures and thereby enable a more efficient assimilation and transformation of this new knowledge. Additionally, the empirical evidence revealed generic changes in the absorptive knowledge base (in terms of its breadth and depth) after each "cycle" of the knowledge absorptive process. This underlines the importance of double-loop learning processes for strengthening firms' AC (cf. Argyris and Schön, 1978).

Second, the findings underpin the argument by Lam (2000) that firms rely simultaneously on embrained and embodied individual knowledge, as well as encoded and embedded collective knowledge, even if these four types of knowledge are not equally important. The results point to the necessity to distinguish between individual and organisational knowledge bases because of their different roles for AC. If individuals have "weak" or unrelated knowledge bases, the firm is not able to recognise relevant external knowledge; if the organisational absorptive knowledge base is "weak" or existing knowledge-processing mechanisms are inadequate, the firm is not able to integrate the acquired knowledge, and consequently to exploit it. This distinction is especially relevant in practice, when firms want to assess and strengthen their AC.

Additionally, based on the empirical findings we propose that absorptive efforts should be considered relevant not only for acquisition, but throughout all stages of the AC process. Indeed, while Song et al. (2018) distinguished two functional roles of absorptive efforts: the primary function ("radar") and the secondary function ("processor") (cf. p.2348), our empirical evidence suggests that these functions can be of equal importance, but target different groups of knowledge carriers involved at different stages in the AC process. In more detail, absorptive efforts during acquisition aim at facilitating the search for relevant knowledge and recognition of its value by strengthening the abilities of a firm's boundary spanners and by creating favourable conditions. The apparent objective of absorptive efforts during later stages of the AC process is to fill knowledge gaps of the key knowledge carriers in this phase and to prepare them for the optimal processing, integration and application of the knowledge acquired by other firm members.

***Heterogeneity in AC configuration and linkage to a firm's strategy and innovation pattern***

The explorative findings of the empirical analysis reveal both commonalities and differences between the AC configurations of the firms (see Table 4.3 and Appendix). At first glance, the identified commonalities seem to contradict the expected heterogeneity in the firms' AC configurations. However, a closer look shows that these commonalities relate primarily to the importance of individuals as the focal point of the firms' AC. The findings underpin the importance of motivation, abilities, power and opportunities, which is in line with previous research on the individual characteristics of the key absorptive agents (e.g. Easterby-Smith et al., 2008; Minbaeva et al., 2003; Todorova and Durisin, 2007). This result is not surprising given that all three cases follow the DUI mode of learning in the absence of a formal R&D department. Instead of relying on the STI mode of learning, which is frequently institutionalised in an R&D department, the three analysed firms draw strongly upon tacit, practical, and experience-based forms of technological knowledge, which originates at the level of individuals.

The results also highlight the firm-specific characteristics of AC patterns. The firms' AC configurations differ from each other in terms of the weight of constitutive

components, either individual or organisational, in terms of the level of formalisation during the different phases of the AC process, and the degree of integration of the AC process into the innovation process. As the empirical insights show, how a firm configures the AC elements corresponds to the nature of its dominant innovation mode and strategic goals.

Accordingly, if we agree that firms differ in their strategies and innovation patterns, we must embrace the idea that heterogeneity can be expected in terms of how they compose and develop their AC to achieve their strategic and innovation goals. The integrative theoretical framework developed in this paper has shown its potential to capture this heterogeneity in an empirical analysis. The key constitutive components proposed in the framework should be considered the key pillars required for building AC. As we regard AC as a dynamic capability (Patterson and Ambrosini, 2015; Zahra and George, 2002), we assume that the key constitutive elements of AC can be generalised across firms, although their actual manifestations and combinations are unique, contextual and firm-specific (Eisenhardt and Martin, 2000). The analysed cases also reveal differences in the manifestations of the key constitutive elements, differences in terms of the vertical and horizontal alignment of elements to each other, as well as differences regarding their fit to the innovation strategy, innovation resources and strategically relevant external knowledge. In line with the resource-based view (e.g. Barney, 1991), resource orchestration (e.g. Carnes et al., 2017; Sirmon et al., 2011) and dynamic capability perspective (e.g. Teece et al., 1997), we consequently assume that the firm gains competitive advantages not by drawing upon single constitutive elements, but through its ability to orchestrate these elements and align the corresponding AC configuration to its strategy and innovation pattern.

### *Implications*

The results of this paper contribute to innovation management research and enhance the *academic* understanding of manufacturing firms' AC. By addressing heterogeneity in AC patterns, this paper makes the concept of AC more applicable and relevant for evolutionary innovation literature, which has long acknowledged heterogeneity in firms' innovation behaviour and empirically distinguished different innovation patterns and

learning modes. More specifically, the paper advances the current understanding of firm-level AC by integrating previously fragmented findings on AC from different research fields into a holistic framework. The proposed framework provides distinct and valuable angles to study the construct and explore the heterogeneity of firms' AC patterns. Moreover, it vertically extends the AC model proposed by Song et al. (2018) by integrating individuals as another constitutive component and elaborating on the multi-level interaction at each stage of the AC process (cf. Marabelli and Newell, 2014; Martinkenaite and Breunig, 2016). This is particularly important for the analysis of AC in firms without formal R&D, which rely strongly on individuals due to less institutionalised innovation activities on the organisational level (cf. Dooley et al., 2017; Rammer et al., 2009). In addition, the framework is particularly suited to less-institutionalised forms of AC that are not based primarily on the STI-mode of innovation (cf. Jensen et al., 2007; Parrilli et al., 2020). Due to its integrated vertical and horizontal perspective, the framework significantly improves the understanding and operationalisation of AC configurations associated with the DUI-mode of innovation, which have been neglected by prevalent AC operationalisations (Lane et al., 2006; Robertson et al., 2012). Thus, the proposed framework provides a comprehensive and holistic basis to understand and empirically measure firms' AC in a more differentiated manner, particularly in non-R&D firms and SMEs.

Secondly, the proposed integrative framework could serve as the first step towards a better operationalisation and measurement of AC on the firm level. It goes beyond proxy indicators and measurement approaches that focus solely on the input or output of AC and do not account for differences in internal configurations, and whether there are idiosyncrasies or commonalities in the AC configurations across firms.

Thirdly, the suggested conceptual framework can serve as a reference to map existing and position future AC research according to its analytical focus and explanatory variables. Besides improving the overview of the connections between different studies, the framework can also help to identify white areas, which call for further empirical and conceptual research.

For *managers and practitioners*, the developed framework could be used as a tool to purposefully structure and strengthen their firm's AC by adjusting it to the firm's

strategic needs and types of external knowledge. On the one hand, it improves their understanding that a firm's AC is composed of different constitutive functional elements on an organisational and individual level that depend on the stage of the AC process. On the other hand, they can use the framework as a maturity model to analyse their own AC configuration, and subsequently define the needs for strategic action. For instance, the framework could raise managers' awareness about the need to underpin the AC efforts on the individual level by processes and routines on the organisational level in order to improve the diffusion and implementation of external knowledge in the company.

Finally, the paper's insights can be used by both *intermediaries and policy makers* to develop and/or improve funding schemes and support services to enhance firms' AC-building in line with their innovation strategy. This might be of particular relevance for innovation networks and clusters between science and industry and cross-industry collaboration.

*Limitation and further research*

As with every study, this paper is not without limitations. The authors are fully aware that both the development of the integrative conceptual framework as well as the empirical analysis are explorative in nature. The developed conceptual AC framework has only been applied to a small case number of selected manufacturing firms following different innovation patterns. Furthermore, the insights gained from the qualitative expert interviews in these cases cannot be statistically generalised in terms of a "proven" concept or "general" evidence that firms' AC configurations are subject to heterogeneity across different types of firms and industries.

Hence, there is the need for further qualitative and quantitative empirical research on the heterogeneous nature of how firms configure their AC elements along the AC process. Along these lines, the following aspects would be of particular interest for future research to improve and further validate the analytical power of the proposed conceptual framework.

Firstly, the framework needs to be applied and tested in a wider range of firms following different innovation patterns. It would be especially interesting to compare

firms that pursue STI and DUI modes of innovation and explore whether and to what extent their AC configurations differ.

Secondly, while our empirical findings show that a firm's innovation behaviour shapes its AC configuration, they do not answer the question whether and to what extent firms following a similar innovation pattern might nevertheless have different AC configurations. Future studies could investigate (a) the relationship between firms' innovation strategies and AC configurations, (b) the factors that moderate or mediate this relationship, (c) whether AC configurations are firm-specific and idiosyncratic, or whether several "typical" patterns can be identified across manufacturing firms and industries, and (d) whether certain AC configurations benefit a firm's innovation performance more than others.

Thirdly, future studies could explore the linkage between the innovation process and the AC process. Is AC a separate process with dedicated resources that occurs in parallel to the innovation process, or is it a generic part of the innovation process, which can only be separated analytically but not practically?

Finally, future research might explore the dynamics within the AC configurations themselves through in-depth, long-term analyses. When do firms change or modify their AC configuration? Does this happen before or after a strategic reorientation? In this context, linking AC research to dynamic capabilities could be particularly interesting to understand the extent to which a firm's AC configuration can be designed by managerial purpose, and to what extent this emerges generically along the operative business.

## APPENDIX

Table 4.4: Firm-specific manifestations of constitutive elements in the acquisition phase

| | Case *Alpha* | Case *Beta* | Case *Gamma* |
|---|---|---|---|
| Individuals | • Managing director<br>• Head of purchasing<br>• Head of production | • Engineers from the technical department (Technical Sales, Construction and Toolmaking) (3-4 persons)<br>• Both managing directors | • Members of Team Technology (both managing directors and 6 further employees from purchasing, marketing/development, production and quality management departments) |
| Absorptive efforts | • Relying on high-status boundary spanners with power, high degree of autonomy and opportunities. | • Regular contacts with various external partners via visits to trade fairs, participation in working groups, congresses, etc.<br>• Management assigns engineers a high degree of autonomy and flexibility in terms of decision-making.<br>• Management empowers engineers to try out new ideas in terms of experiments and tests (but only if the expected results are of high strategic relevance).<br>• Management consciously aims at increasing the motivation of key knowledge workers (engineers and process developers) by encouraging them to undertake challenging and varied tasks. | • Open culture with positive working atmosphere and high failure tolerance: All employees are encouraged to bring new ideas and share them with colleagues.<br>• Management empowers the key boundary spanners to take responsibility, test new things, and learn through experimenting.<br>• Opportunities for firm's key boundary spanners in terms of external qualification measures and trainings.<br>• Regular meetings in a broader setting, whose aim among other things is to provide employees with a broad overview of the firm's activities, priorities, and problems to be solved. |

Table 4.5: Firm-specific manifestations of constitutive elements during the assimilation and transformation phases

| | Case *Alpha* | Case *Beta* | Case *Gamma* |
|---|---|---|---|
| Individuals | • Managing director, Head of production and Head of purchasing<br>• Middle managers<br>• Employees from different departments (e.g. IT, marketing, product development) | • Engineers from the technical department (Technical Sales, Construction & Toolmaking)<br>• Production employees responsible for manufacturing process engineering | • Members of cross-functional Team Technology<br>• Both top managers |
| Absorptive knowledge base | Firm's collective knowledge base is:<br>• Embedded in diverse agile meeting structures (with varying regularity and composition of participants)<br>• Encoded via documentation (database, intranet, email-distribution list)<br>• Collection and documentation of internal inputs: once a year the employees have the chance to write down and share their ideas, insights, challenges, etc. | • Collective encoded knowledge:<br>- related to engineering in terms of documentation of experiments and tests, machine specifications, lessons learned etc.<br>- related to production in terms of work instructions, formalised rules and documented procedures (instructions for the set-up of machinery, product control plans etc.)<br>• Collective tacit knowledge and process know-how embedded in procedures, communication structures, etc. | • Knowledge base embedded in formal and informal communication structures and procedures<br>• Knowledge encoded in the project database, where relevant external impulses, gained experience, results, insights and lessons learned are gathered. |

(Table 4.5 Continued)

| | Case *Alpha* | Case *Beta* | Case *Gamma* |
|---|---|---|---|
| Absorptive processes | • Cross-functional interfaces through diverse agile meeting structures (with varying regularity and composition of participants)<br>• Experience transfer from "old" to "young" (e.g. preparing successor for key boundary spanners to secure the sustainable knowledge flow from the external environment into the firm)<br>• "Train-the-college" concept (transfer of organisational, cumulative knowledge to less experienced employees, sharing of relevant, individual-based knowledge between employees)<br>• Job rotation of production staff (sharing of practical knowledge and experience between workers engaged in different production areas) | • Positioning of internal boundary spanners (process developers)<br>• Process developers are enabled and encouraged to participate in the decision-making process during the assimilation phase<br>• Regular task- and project-oriented meetings within the engineering departments with the involvement of managing directors<br>• Informal meetings and communication between engineers<br>• Cross-functional task-oriented communication on-demand between engineers and production staff<br>• Formalisation and routinization mechanisms in terms of setting rules and procedures, sequences of tasks | • Participation of members of Team Technology in decision- making<br>• Cross-functional structure: e.g. Marketing and Development work as one business unit<br>• Regular cross-functional meetings of Team Technology (different areas of expertise are brought together in this team)<br>• Created opportunities for informal meetings and knowledge exchange |
| Absorptive efforts | • Working conditions make it possible for employees to dedicate time and financial resources to learning new things<br>• External training and competence development of employees involved in processing external knowledge<br>• Production employees are encouraged to take part in visits to trade fairs to enhance their individual knowledge base | • Task-specific qualification measures for production workers (machine operators, machine setters and process developers), mostly external or in-house training organised by the machine suppliers<br>• Enhancing the motivation of production workers by incorporating them into the development of new manufacturing process through learning-by-doing | |

# CHAPTER 5

## Conclusion

This section of the dissertation summarises the results obtained in the three research papers and presents the major contributions from the perspective of academic innovation research, innovation management and innovation policy. It finishes by shedding light on the limitations of this dissertation and identifying opportunities for future research.

### 5.1 CONTRIBUTIONS TO INNOVATION RESEARCH

The purpose of this dissertation was to advance our understanding about how non-R&D-performing manufacturing firms build their AC to access and leverage external knowledge in their innovation activities. By responding to this overall research objective, this dissertation contributes to innovation management research and enriches the AC literature in several important ways.

First, it responds to the call to explore the concept of AC beyond the R&D-based context (Lane et al., 2006; Lewin et al., 2011) and examines it in the overlooked, but highly relevant, empirical context of non-R&D-performing manufacturing firms (Empirical gap). By providing novel empirical insights into the specifics of AC in non-R&D firms based on recent qualitative and quantitative data, this dissertation broadens our understanding of AC and offers a more differentiated perspective beyond R&D-based efforts and the institutionalised R&D unit. Second, the dissertation integrates fragmented findings from different streams of AC research and proposes a comprehensive conceptual framework of AC, which allows a more nuanced, differentiated understanding of firm-specific AC configurations (Conceptual gap 1). Third, this dissertation provides pioneering insights into the heterogeneity in AC patterns, which has been overlooked to date (Conceptual gap 2), and explains how AC configurations are shaped by a firm's dominant mode of innovation behaviour and innovation patterns. Finally, the dissertation, and in particular the developed framework, provides the starting point for better operationalisation of the construct and for the development of more comprehensive

measures of AC, which can be applied in a broader empirical context of firms with any level of R&D intensity. These contributions are discussed in more detail in the following section.

***Deeper understanding of AC beyond the R&D-based context***

By studying AC in a different empirical setting, this dissertation contributes to the external validity of the concept of AC (cf. Chesbrough and Crowther, 2006). The empirical results indicate that non-R&D firms are no different from R&D-performing firms in terms of their openness to external knowledge and the most prevalent search patterns (cf. Chapter 3). This underlies the argument that, as for R&D firms, openness to external innovation sources is a promising approach for non-R&D firms as well to achieve innovation success (cf. Chesbrough and Crowther, 2006; Dooley and O'Sullivan, 2018; Santamaría et al., 2009). This finding can serve as evidence that non-R&D firms possess at least the minimum level of necessary AC, since research has previously agreed that some level of AC is required to benefit from open innovation activities (e.g. Zobel, 2017). Further, the extensive analysis reveals a number of similarities between non-R&D firms and findings of previous research in terms of the AC process and AC configurations, but also that non-R&D firms have some particularities.

On the one hand, the empirical findings for non-R&D firms presented in detail in the three research papers suggest that the main pillars of AC from the mainstream AC literature are also transferable to the non-R&D-based context. Specifically, the AC process in non-R&D firms embraces the same underlying dimensions proposed in previous literature (cf. Zahra and George 2002) and the related organisational practices and routines are comparable with those described for R&D-intensive firms (e.g. Duchek, 2015a; Horvat, 2015; Wagner, 2012). The same applies to the constitutive components transverse to the process dimensions. The analysis identified these organisational components: absorptive efforts, absorptive knowledge base, absorptive processes (cf. Song et al., 2018), and their manifestations correspond to what is known from the mainstream literature (e.g. training and learning activities, cross-functional interfaces, participation in decision-making, formalisation, etc.).

On the other hand, the findings of this dissertation indicate that non-R&D firms have certain particularities in terms of the type and characteristics of the relevant knowledge they absorb, the nature of the AC process, as well as the available personnel and organisational resources they can allocate to configure their AC. And these particularities can be traced back to the dominant learning mode and patterns of innovation behaviour in these firms, which are, as a rule, different from those of R&D-performing firms (cf. Som, 2012; Thomä and Zimmermann, 2020).

First, the quantitative analysis in Chapter 3 reveals that, compared with their R&D-performing counterparts, non-R&D firms are more likely to search for supplier-based knowledge and less likely to search for science-based knowledge. This is in line with the qualitative findings in Chapter 2 that industrial partners are the main source of technological knowledge and new trends for these firms. Universities also play an important role for the analysed non-R&D firms. Although scientific knowledge is usually characterised as explicit, formal and theoretical (e.g. Koehler et al., 2012; Lam, 2000), the analysis in Chapters 2 and 4 reveals that non-R&D firms are strongly interested in the tacit knowledge and informal exchange with their scientific partners.

Second, Chapter 2 suggests that the AC process in the analysed firms is rather informal and more intuitive, and these firms are likely to pursue "local" search aiming at incremental innovations. Moreover, the AC process of non-R&D firms is broadly anchored in different functional areas. In the absence of a R&D department, non-R&D firms rely heavily on engineers, because of their strong academic technical background, as well as on departments with close customer contact, such as marketing and customer service (Chapter 2 and Chapter 3). Manufacturing employees also play an important role, but tend to be innovation drivers rather than AC promoters, and hence are mainly involved at the phase of exploitation of newly acquired external knowledge in the innovation process.

Third, the findings of Chapter 2 and Chapter 4 indicate that the resource constraints of non-R&D firms (cf. Moilanen et al., 2014; Rammer et al., 2009) shape the way these firms configure their AC. For instance, compared with R&D-intensive firms, as a rule non-R&D firms have a below-average share of highly educated employees (cf. Som, 2012) and, as the interviews revealed, their AC process is built around a few key

highly educated and experienced individuals. Every one of these individuals is crucial for the firm's AC. In other words, AC configuration in non-R&D firms can be characterised as individual-centred. The decisive factor here is the integration of these key individuals in the AC process by means of appropriate organisational practices. Absorptive efforts that make key individuals "fit" for their role in the AC process are particularly important.

These findings imply that some of the lessons learned from large, R&D-intensive firms are not directly transferable to the context of non-R&D firms. Hence, researchers need to revise the original assumptions underlying the AC concept. For instance, the assumptions about the necessity of R&D to successfully absorb technological knowledge, or the need for a high share of highly educated employees should be questioned (see Chapter 2 for more details).

### *Integrated conceptual framework of AC and holistic understanding of the AC configuration*

This dissertation makes a substantial contribution to better understanding the internal organisation of AC, which has not been elaborated in previous research (Conceptual gap 1) by proposing a holistic conceptual framework (Chapter 4). This framework integrates three main streams of AC literature (the process-based perspective, the perspective of constitutive elements, and the perspective of AC microfoundations) across different areas of research (e.g. innovation management, interorganisational learning, interorganisational transfer of knowledge, new product development and open innovation). Thus, the developed framework can capture the AC configuration in its fullness by considering process phases, different constitutive elements and their manifestations on the level of individuals and organisation, as well as accounting for multi-level interactions at each phase of the AC process. It is worth noting that the findings concerning the diverse constitutive elements should not be interpreted as though R&D is not important for AC. Rather, its relevance depends on the context within which knowledge absorption takes place.

Moreover, by integrating the mainstream AC literature with the particularities of non-R&D firms (elaborated in Chapter 2 and 3), the framework offers a more

differentiated perspective of AC and thereby an opportunity to explore heterogeneity in AC patterns in different types of firms. Illustrated and tested using qualitative data collected in non-R&D firms, this framework shows its particular strength in capturing the AC configurations associated with the search and absorption of tacit, practical knowledge in the context of the DUI mode of innovation and learning.

Additionally, this dissertation brings more conceptual clarity to some of the aspects of the AC configuration that have not received much attention in previous AC research, but are useful for advancing the theoretical development of the AC concept. First, it provides wider understanding of the organisational embeddedness of the AC process. Chapters 2 and 3 emphasise the role of different functional areas and their involvement during different stages of the AC process (cf. Bogers and Lhuillery, 2011). The findings imply that the AC process can be anchored in different functional areas. Based on differences in their areas of expertise and their degree of exposure to external knowledge in daily operations, there is evidence of specialisation among functional areas in terms of the type of external knowledge they bring into the organisation and their role at the different stages of the AC process. Second, Chapter 2 and Chapter 4 of this dissertation contribute to a multi-level perspective (Distel, 2017; Martinkenaite and Breunig, 2016; Sjodin et al., 2019) by offering first insights into the vertical integration of the constitutive elements of AC along the entire AC process. The results advocate the necessity of aligning individuals and organisational practices for a firm to be able to benefit from AC.

***Pioneering insights into inter-firm heterogeneity in AC configurations***

Another important conceptual contribution of this dissertation is the description and explanation of the heterogeneity in AC configurations across different firms (Conceptual gap 2). On the one hand, the quantitative data analysis in Chapter 3 supports the idea of distinctive modes of knowledge absorption, which reflect different types of external knowledge. The findings show that, in non-R&D firms, the DUI mode of AC prevails (targeting tacit knowledge from industrial sources and relying on the customer service department and non-R&D-based cooperation). However, some non-R&D firms have AC associated with the STI mode of learning and innovations. The interviews support this

finding and suggest that STI-based knowledge is of high strategic relevance for this group of non-R&D firms and that they engage in efforts to be able to leverage this more complex knowledge.

On the other hand, qualitative findings in Chapter 2 and especially Chapter 4 highlight another source of inter-firm heterogeneity in AC configurations, namely a firm's dominant mode of innovation behaviour and innovation pattern. As the frontend of the innovation process, AC is directed towards knowledge types relevant for a firm's innovation pattern and AC configuration appears to be shaped by the firm's innovation resources.

A connection between heterogeneity in AC configurations and the characteristics of relevant external knowledge, the availability of certain internal innovation resources, and especially the innovation behaviour of the firms implies that AC should be recognised as a context-specific construct. Thus, future research needs to shift towards a broader, more differentiated understanding of AC and consider its contextual contingencies.

### *New requirements for measuring AC*

Despite the growing popularity of AC in recent research, comprehensive measures that reflect the richness and complexity of the AC construct are still missing (Flatten et al., 2011; Lewin et al., 2011; Murovec and Prodan, 2009; Volberda et al., 2010). A better understanding of how to operationalise and measure AC is necessary to make theoretical progress (cf. Venkatraman and Grant, 1986). The empirical findings of this dissertation on inter-firm heterogeneity in AC configurations underline the need to improve and adjust the conceptualisation and operationalisation of the AC concept.

The proposed integrated framework could form the cornerstone for developing a more comprehensive measurement of AC beyond R&D-related proxy indicators and approaches focusing solely on the input or output of AC that do not account for differences in internal AC configuration. On the one hand, the framework shows the main pillars of AC that should be measured to capture the AC construct in its fullness and address its multidimensionality, multifaceted nature and multi-levelness. On the other hand, considering that it is not always feasible or relevant to the research objective to measure the construct in its full complexity, the framework can also serve as a mapping

tool. It can allow researchers to communicate better which aspect of the AC concept is of relevance for their research objective, whether the measures used are appropriate to capture this aspect and applicable to the empirical context, and which limitations such an approach has. For instance, R&D investments can be a good measure of AC if research aims at capturing science-driven AC of the R&D unit in the context of new product development. In contrast, this measure would be inefficient if the research focus lay on the absorption of process-oriented supplier knowledge in firms whose dominant innovation and learning mode is based on "doing, learning and interacting".

To summarise, this dissertation identified heterogeneous AC patterns in non-R&D firms. Although these patterns seem to fit well into a general AC framework in terms of AC dimensions and constitutive components, they display particularities and differ from what has been previously described in the AC literature on how firms can build their AC. Further, the findings of this dissertation provide the first indication that these patterns are likely to be more prevalent in non-R&D firms. However, they do not imply that only non-R&D firms can have such patterns of knowledge search and absorption. This is consistent with recent literature on non-R&D innovation, which indicates that there are hardly any "typical" non-R&D innovation patterns, and that many similar patterns can be found in both R&D and non-R&D firms (e.g. Dreher et al., 2018).

Instead, the findings were able to uncover and highlight some aspects of AC that have been neglected in previous research, e.g. AC in the context of the DUI mode of learning and innovations, such as process innovations, the absorption of tacit, embedded, practical knowledge, and the organisational embeddedness of AC beyond the R&D unit. These factors shape the way firms build their AC and thus lead to heterogeneous AC compositions. In this sense, it might be more meaningful not to distinguish between R&D and non-R&D AC configurations, but rather to consider AC as a heterogeneous construct with a wide variety of manifestations. To account for this heterogeneity, this dissertation points to the necessity of explicitly defining the context in which knowledge absorption takes place by answering the following questions: Which type of external knowledge is being absorbed, what is the desired outcome of such knowledge absorption, what innovation resources are available, and how is the firm's existing knowledge base stored?

## 5.2 CONTRIBUTIONS TO INNOVATION MANAGEMENT

In a digital era, understanding AC, how it arises and can be strengthened, is becoming increasingly important for companies to sustain competitive advantages, especially considering such challenges as knowledge intensification, individualised customer requirements, digital transformation in manufacturing, and the emergence of new technologies with disruptive potential. In this respect, the findings of this dissertation have several important implications for practitioners and decision-makers in companies.

First, the conceptual framework developed represents an instrument for assessing a firm's strengths and weaknesses in terms of AC. It makes it possible to evaluate the single phases of the AC process. Thereby, it can help the management of a company to better understand the functions of the underlying AC dimensions and give them examples of how to strengthen practices and instruments if necessary, depending on the strategic objective. For instance, strengthening the acquisition phase would increase the amount of external knowledge flowing into a firm, renew a firm's knowledge stock and thus help to avoid the competence trap. However, it would not necessarily lead to an exploitation of this knowledge.

Second, taking into account that AC and its underlying efforts can be cost-intensive (e.g. Som et al., 2013), findings of this dissertation suggest that it is economically reasonable for a company to align its AC with the business and innovation strategy appropriate for the firm's environment. Accordingly, management should consider AC as an integral part of the company's innovation activities, and devote sustained attention to building an efficient AC process. It could also be beneficial for a firm to define a coherent AC strategy determining (a) which external knowledge is strategically valuable for its innovation pattern and (b) which innovation resources should be allocated to deploy such AC.

Third, it might be worth making strategic use of industrial sources of external knowledge. Companies might recognise customers and suppliers as valuable sources of technological knowledge that is less complex, easier to access and directly applicable compared with scientific knowledge. By building a longstanding symbiotic relationship with R&D-intensive industrial partners, a firm can gain access to pre-selected and

"translated" scientific knowledge. In this way, it can keep up-to-date with the latest technological trends and developments.

Regarding the relevant underlying resources and practices, the results draw attention to the decisive role of individuals in the AC process, their motivation, abilities and opportunities. Therefore, it is crucial for management to identify key individuals, assign them particular roles in the AC process and position them accordingly. It is also necessary to invest in the qualification of key absorptive agents to enhance their individual ACs and make them "fit" for their function in the AC process. Moreover, the role of management as AC champions and shepherds of externally acquired ideas should not be underestimated. In addition, this dissertation provides a complementary perspective on the role of individuals as its findings show that not only R&D staff, but also employees with a strong technical background from other departments can be prominent absorptive agents for acquiring and integrating technological knowledge. In this vein, firms should be aware of the strengths of different functional areas and integrate them consciously in the AC process according to their competences.

Finally, as non-R&D firms and SMEs are often influenced by the accounts and experiences of other companies (Chesbrough and Vanhaverbeke, 2018), this dissertation can be relevant for company decision-makers by providing a number of concrete examples and useful impulses from non-R&D-firms that have built sufficient AC and are successful in utilising external knowledge in their innovation processes. By demonstrating the necessity to widen the space and use the opportunities for maintaining AC by relying on sources and efforts other than R&D-based ones, the findings of this dissertation have implications for decision-makers in R&D-performing companies as well.

## 5.3 CONTRIBUTIONS TO INNOVATION POLICY

Non-R&D firms, including SMEs, are a relevant, integral part of the innovation ecosystem (Som, 2012; Hirsch-Kreinsen, et al. 2015; Dooley and Sullivan, 2018). They are not less innovative per se and do not differ from innovative firms with in-house R&D in terms of economic performance measured by a change in revenues (Arundel et al., 2008). Findings for the German manufacturing sector suggest that non-R&D firms have comparable levels of productivity, manufacturing speeds and quality of products and production processes as their R&D-performing counterparts (Kirner et al., 2015; Som, 2012). In addition, non-R&D firms are open towards external knowledge impulses (Heidenreich, 2009; Hirsch-Kreinsen, 2015) and successfully implement open innovation activities (Chesbrough and Crowther, 2006; Dooley and O'Sullivan, 2018). Nonetheless, non-R&D innovators are not properly supported by policy (Dreher et al., 2018; Moilanen et al., 2014; Som, 2012).

The results of this dissertation imply that policy makers should not underestimate the openness of non-R&D firms to external knowledge. Indeed, the absence of R&D does not necessarily mean low levels of the knowledge intensity of innovation or a lower reliance on external knowledge inputs. In fact, the findings of this dissertation reveal that non-R&D firms have a comparable degree of openness across different fields of innovation to their R&D counterparts.

Nonetheless, non-R&D firms have their own particularities in knowledge search and absorption and policy makers should consider these when designing innovation policies. Therefore, the findings of this dissertation indicate the need for policy makers to reflect the particular strengths of non-R&D firms and supplement existing programmes with policy instruments that better support them in developing sufficient AC directed towards strategically relevant knowledge.

First, the findings underscore the particular importance of individuals for the AC of non-R&D firms. Hence, an important task of innovation policy is to promote better management of human resources and make it attractive for non-R&D firms to hire highly qualified personnel and invest in training and learning programmes (cf. Chesbrough and Vanhaverbeke, 2018).

Second, the findings of this dissertation point to the necessity of support to strengthen the internal capabilities of the functional areas of engineering, marketing and manufacturing as these appear to be important drivers of firms' AC.

Third, as non-R&D firms appear to rely strongly on impulses from industrial partners, these could play the role of intermediaries facilitating the translation of complex, science-based knowledge into practical, relevant knowledge that is directly applicable in non-R&D firms. In this vein, non-R&D firms might outsource some phases of the AC process to these intermediaries.

Moreover, the results of this dissertation underscore the idea that there is no "one-size-fits-all" solution. It is important to adjust existing policy instruments by taking into account the heterogeneity of innovation patterns and the specifics of related AC configurations in non-R&D firms in order to reach these firms through appropriate, specialised transfer channels (cf. Dreher et al., 2018; Som, 2012).

Overall, by considering a broader perspective of AC and its quantitative measures, policy makers can better target non-R&D-intensive firms and improve funding schemes and support services to encourage these firms to gain competitive advantages by increasing their AC. Strengthening the AC of non-R&D firms may have a positive "collateral" effect on the whole innovation ecosystem.

## 5.4 LIMITATIONS AND FUTURE RESEARCH

Like any research, this dissertation and its findings are also subject to limitations, which may provide starting points for further research. First, this dissertation investigates AC, its internal organisation and the heterogeneity of AC patterns in the context of non-R&D-performing manufacturing firms. Accordingly, the findings of this dissertation are restricted by the formal definition of R&D and – vice versa - the definition of "non-R&D". Considering that smaller firms fail to report R&D because of the lack of a clear definition (Som, 2012) and conduct informal R&D activities, the results, especially of the quantitative analysis, could be biased by underreported R&D. In this dissertation, I have made the cautious assumption that firms without institutionalised R&D departments and full-time R&D staff probably have very low R&D intensity even if they carried out R&D activities informally. This is unlikely to affect the findings substantially. However, future

research could take a closer look at this problem by comparing firms without R&D with those with a low R&D intensity and examining whether the results regarding the specifics of AC in non-R&D firms also hold for firms with a low R&D intensity.

Second, this dissertation has some methodological limitations. On the one hand, the second paper of this dissertation is subject to the limitations typical for quantitative research applying cross-sectional data. In particular, the data used leave little room to control for endogeneity and potential reverse causality and provide insights only into the correlations between different search patterns and related manifestations of internal AC organisation. The use of longitudinal data would allow for the temporal sequencing of dependent and independent variables, and thus reducing the potential endogeneity bias and enabling to account for causal relationships. Furthermore, future studies could apply a longitudinal research design to scrutinise the dynamics of a firm's AC and explore how firms can overcome the constraints of their current AC configuration to be able to absorb relevant, but more complex knowledge from more distant domains.

On the other hand, the first and the third papers rely on qualitative data from multiple case studies, which are of an explorative nature. Qualitative research findings obviously cannot be generalised. The underlying objective of the empirical analysis was to explore the process of AC in non-R&D firms, illustrate the constitutive components of their AC configurations and provide first insights into the inter-firm heterogeneity. While the number of selected cases and number of conducted interviews are justified within the objective of this dissertation, further qualitative and quantitative investigations are needed to validate and enrich the presented results.

For instance, internal configurations of AC in non-R&D firms can be examined in a broader empirical setting by relying on quantitative survey data. Since the German Manufacturing Survey contains only a few relevant indicators, in a new wave of the survey, further indicators can be included to measure AC in a more comprehensive way. These are for example key individuals responsible for external knowledge search, promoters of AC within an organisation (their educational level, position, organisational embeddedness), or diverse organisational practices facilitating knowledge sharing. The integrated framework developed in Chapter 4 can be used as a starting point to

operationalise constitutive components that could capture the AC configuration in its fullness.

Representative, cross-sectional survey data could also allow to validate the findings on the heterogeneity in AC configurations, identify most common AC patterns and establish links between AC patterns and a firm's innovation strategy. In fact, while the quantitative study theoretically assumes the fit between a firm's innovation strategy and its AC configuration, the questionnaire provides no appropriate measures for a firm's innovation mode to test this assumption empirically. Future research could try to shed more light on this aspect and deepen our understanding of the role of a firm's strategy and innovation modes for AC configuration. It could be interesting to extend this dissertation and explore the interrelations between the AC configuration and the firm's dominant innovation mode by integrating recent studies on the STI and DUI innovation modes (e.g. Alhusen and Bennat, 2021; Fitjar and Rodríguez-Pose, 2013; Parrilli and Heras, 2016; Parrilli and Radicic, 2021).

Moreover, since AC is a context-specific construct and environmental factors are suggested to play a crucial role in shaping AC (e.g. Van Den Bosch et al., 1999; Volberda et al., 2010), future studies should validate the transferability of results in different empirical settings: in different firms, different environmental settings and with larger samples. For example, while I believe there is no specific reason why the heterogeneity assumption should not hold in other national settings, extending research to other countries could validate and generalize the findings. The very same data set of the European Manufacturing Survey conducted by Fraunhofer ISI is available for other ten European countries in addition to the German data, which I use in this dissertation. The use of these data makes it very feasible to replicate the quantitative findings of the second paper applying the same variables and measures. Subsequent research could also extend the findings on the particularities of AC in non-R&D firms in the manufacturing industry by examining non-R&D-performing firms in the service sector. Another promising direction for future qualitative and quantitative studies could be to elaborate on the differences between non-R&D and R&D firms in terms of their AC configurations. Qualitative and quantitative research designs can be applied. A comparative analysis could help to answer the questions of whether some configurations are typical for non-

R&D firms only or whether AC configurations are comparable between two groups of firms (with an exception of R&D-centred AC, which can obviously be present in R&D firms only).

Due to the data limitations, in the quantitative analysis, I consider customer-, supplier- and science-driven search patterns to be independent, while several previous studies point to the interrelation between different types of external knowledge sources (Grimpe and Sofka, 2009, 2016; Haus-Reve et al., 2019). In line with these studies, the qualitative findings demonstrate that non-R&D firms combine different external knowledge sources in their innovation activities. Therefore, future research could address the interplay between different external knowledge sources and examine in more detail how firms combine different types of knowledge in their search activities. It could be interesting to explore the complementarity and substitution between different types of knowledge sources and link the identified search patterns to the internal organisation of corresponding ACs. Moreover, it could be interesting to compare different fields of innovations (e.g. product, process, product-related service and organisational innovations) in terms of possible complementarities and synergies between different external knowledge sources.

Finally, the scope of this dissertation was deliberately narrowed down to the frontend of the AC process, namely the acquisition, assimilation and transformation phases. In fact, while the dissertation provides a high level of detail on the internal configuration of AC, it does not elaborate on the "performance" of AC configurations. Consequently, future research could extend this dissertation and explore which configurations are more likely to result in improved AC "performance" and under which conditions: whether specific combinations of the main pillars of AC enable larger, faster or more accurate acquisition of valuable knowledge and are more likely to lead to an innovation outcome or improved firm performance.

# REFERENCES


Alhusen, H., Bennat, T., 2021. Combinatorial innovation modes in SMEs: mechanisms integrating STI processes into DUI mode learning and the role of regional innovation policy. European Planning Studies 29 (4), 779–805.

Argote, L., McEvily, B., Reagans, R., 2003. Managing knowledge in organizations: An integrative framework and review of emerging themes. Management science 49 (4), 571–582.

Argyris, C., Schön, D.A., 1978. Learning organizations: A theory of action perspective. Reading, MA: Addison-Westley.

Arundel, A., Bordoy, C., Kanerva, M., 2008. Neglected innovators: How do innovative firms that do not perform R&D innovate: Results of an analysis of the Innobarometer 2007 survey No. 215. INNO-Metrics Thematic Paper.

Barge-Gil, A., Jesus Nieto, M., Santamaría, L., 2011. Hidden Innovators: The role of non-R&D activities. Technology Analysis and Strategic Management 23 (4), 415–432.

Barney, J., 1991. Firm resources and sustained competitive advantage. Journal of Management 17 (1), 99–120.

Becheikh, N., 2013. The Impact of Knowledge Acquisition and Absorptive Capacity on Technological Innovations in Developing Countries: Evidence From Egyptian Small and Medium-Sized Enterprises. Journal of African Business 14 (3), 127–140.

Bender, G., 2008. How to grasp innovativeness of organizations: Outline of a conceptual tool, in: Hirsch-Kreinsen, H., Jacobson, D. (Eds.), Innovation in low-tech firms and industries. Edward Elgar Publishing.

Bogers, M., Lhuillery, S., 2011. A functional perspective on learning and innovation: Investigating the organization of absorptive capacity. Industry and Innovation 18 (6), 581–610.

Burcharth, A. de, Lettl, C., Ulhøi, J.P., 2015. Extending organizational antecedents of absorptive capacity: Organizational characteristics that encourage experimentation. Technological Forecasting and Social Change (90), 269–284.

Caloghirou, Y., Protogerou, A., Tsakanikas, A., 2014. Exploring knowledge-intensive entrepreneurship in high-tech and low-tech manufacturing sectors: Differences and similarities, in: Hirsch-Kreinsen, H., Schwinge, I. (Eds.), Knowledge-intensive entrepreneurship in low-tech industries. Edward Elgar Publishing, pp. 17–41.

Camisón, C., Forés, B., 2010. Knowledge absorptive capacity: New insights for its conceptualization and measurement. Journal of Business Research 63 (7), 707–715.

Carnes, C.M., Chirico, F., Hitt, M.A., Huh, D.W., Pisano, V., 2017. Resource orchestration for innovation: Structuring and bundling resources in growth-and maturity-stage firms. Long Range Planning 50 (4), 472–486.

Cassiman, B., Veugelers, R., 2000. External technology sources: Embodied or disembodied technology acquisition. Working Paper UPF 444, 1–22.

Cassiman, B., Veugelers, R., 2006. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. Management science 52 (1), 68–82.

Chen, J., Chen, Y., Vanhaverbeke, W., 2011. The influence of scope, depth, and orientation of external technology sources on the innovative performance of Chinese firms. Technovation 31 (8), 362–373.

Chesbrough, H., 2003. Open innovation: The new imperative for creating and profiting from technology. Harvard Business Press.

Chesbrough, H., Crowther, A.K., 2006. Beyond high tech: early adopters of open innovation in other industries. R&D Management 36 (3), 229–236.

Chesbrough, H.W., Vanhaverbeke, W., 2018. Open innovation and Public Policy in the EU with Implications for SMEs, in: Vanhaverbeke, W., Frattini, F., Roijakkers, N., Usman, M. (Eds.), Researching Open Innovation in SMEs. World Scientific, pp. 455–492.

Cockburn, I., Henderson, R.M., 1998. Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery. Journal of Industrial Economics 46 (2), 157–182.

Cohen, W.M., Levinthal, D.A., 1989. Innovation and learning: The two faces of R & D. The Economic Journal 99 (397), 569–596.

Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly 35 (1), 128–152.

Creswell, J.W., 2013. Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

Crossan, M.M., Lane, H.W., White, R.E., 1999. An organizational learning framework: From intuition to institution. Academy of Management Review 24 (3), 522–537.

Dahlander, L., Gann, D.M., 2010. How open is innovation? Research Policy 39 (6), 699–709.

de Jong, J. P.J., Freel, M.S., 2010. Absorptive capacity and the reach of collaboration in high technology small firms. Research Policy 39 (1), 47–54.

Distel, A.P., 2017. Unveiling the microfoundations of absorptive capacity: A study of Coleman's Bathtub model. Journal of Management, 2014-2044.

Dooley, L., Kenny, B., O'Sullivan, D., 2017. Innovation capability development: Case studies of small enterprises in the LMT manufacturing sector. Small Enterprise Research 24 (3), 233–256.

Dooley, L., O'Sullivan, D., 2018. Open innovation within the low-technology SME sector, in: Vanhaverbeke, W., Frattini, F., Roijakkers, N., Usman, M. (Eds.), Researching Open Innovation in SMEs. World Scientific, pp. 249–271.

Dreher, C., Som, O., Kovač, M., 2018. Innovation patterns of SME and innovation policies - The German case of heterogeneity in innovation behaviour and it's impact on policy making. Paper presented at the International Schumpeter Society Conference, Seoul, 02.-04.07.2018.

Duchek, S., 2015a. Designing absorptive capacity? An analysis of knowledge absorption practices in German high-tech firms. International Journal of Innovation Management 19 (04), 1550044.

Duchek, S., 2015b. Enhancing Absorptive Capacity for Innovation and Change: The Role of Structural Determinants. Journal of Change Management 15 (2), 142–160.

Easterby-Smith, M., Graça, M., Antonacopoulou, E., Ferdinand, J., 2008. Absorptive capacity: A process perspective. Management Learning 39 (5), 483–501.

Ebers, M., Maurer, I., 2014. Connections count: How relational embeddedness and relational empowerment foster absorptive capacity. Research Policy 43 (2), 318–332.

Ebersberger, B., Herstad, S.J., Iversen, E., Kirner, E., Som, O., 2011. Analysis of innovation drivers and barriers in support of better policies: Economic and market intelligence on innovation. European Commission. Enterprise and Industry, Oslo.

Edmondson, A.C., McManus, S.E., 2007. Methodological fit in management field research. Academy of Management Review 32 (4), 1246–1264.

Ehls, D., Polier, S., Herstatt, C., 2020. Reviewing the field of external knowledge search for innovation: Theoretical underpinnings and future (re-) search directions. Journal of Product Innovation Management 37 (5), 405–430.

Eisenhardt, K.M., 1989. Building theories from case study research. Academy of Management Review 14 (4), 532–550.

Eisenhardt, K.M., Graebner, M.E., 2007. Theory building from cases: Opportunities and challenges. Academy of Management Journal 50 (1), 25–32.

Eisenhardt, K.M., Martin, J.A., 2000. Dynamic capabilities: what are they? Strategic Management Journal, 1105–1121.

Enkel, E., Heil, S., 2014. Preparing for distant collaboration: Antecedents to potential absorptive capacity in cross-industry innovation. Technovation 34 (4), 242–260.

Enkel, E., Heil, S., Hengstler, M., Wirth, H., 2017. Exploratory and exploitative innovation: To what extent do the dimensions of individual level absorptive capacity contribute? Technovation 60, 29–38.

Eriksson, P., Kovalainen, A., 2015. Qualitative methods in business research: A practical guide to social research. Sage.

Escribano, A., Fosfuri, A., Tribó, J.A., 2009. Managing external knowledge flows: The moderating role of absorptive capacity. Research Policy 38 (1), 96–105.

Fabrizio, K.R., 2009. Absorptive capacity and the search for innovation. Research Policy 38 (2), 255–267.

Fainshmidt, S., Wenger, L., Pezeshkan, A., Mallon, M.R., 2019. When do dynamic capabilities lead to competitive advantage? The importance of strategic fit. Journal of Management Studies 56 (4), 758–787.

Felin, T., Foss, N.J., Heimeriks, K.H., Madsen, T.L., 2012. Microfoundations of routines and capabilities: Individuals, processes, and structure. Journal of Management Studies 49 (8), 1351–1374.

Fitjar, R.D., Rodríguez-Pose, A., 2013. Firm collaboration and modes of innovation in Norway. Research Policy 42 (1), 128–138.

Flatten, T.C., Engelen, A., Zahra, S.A., Brettel, M., 2011. A measure of absorptive capacity: Scale development and validation. European Management Journal 29 (2), 98–116.

Fosfuri, A., Tribó, J.A., 2008. Exploring the antecedents of potential absorptive capacity and its impact on innovation performance. Omega 36 (2), 173–187.

Freel, M.S., 2005. Patterns of innovation and skills in small firms. Technovation 25 (2), 123–134.

Gebauer, H., Worch, H., Truffer, B., 2012. Absorptive capacity, learning processes and combinative capabilities as determinants of strategic innovation. European Management Journal 30 (1), 57–73.

Gehrke, B., Frietsch, R., Neuhäusler, P., Rammer, C., Leidmann, M., 2013. Re-definition of research-intensive industries and goods: NIW/ISI/ZEW-Lists 2012. Studien zum deutschen Innovationssystem.

Gemünden, H.G., Salomo, S., Hölzle, K., 2007. Role models for radical innovations in times of open innovation. Creativity and innovation management 16 (4), 408–421.

Gibbert, M., Ruigrok, W., Wicki, B., 2008. What passes as a rigorous case study? Strategic Management Journal 29 (13), 1465–1474.

Gioia, D.A., Corley, K.G., Hamilton, A.L., 2013. Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. Organizational research methods 16 (1), 15–31.

Grimpe, C., Sofka, W., 2009. Search patterns and absorptive capacity: Low- and high-technology sectors in European countries. Research Policy 38 (3), 495–506.

Grimpe, C., Sofka, W., 2016. Complementarities in the search for innovation-Managing markets and relationships. Research Policy 45 (10), 2036–2053.

Hatzichronoglou, T., 1997. Revision of the high-technology sector and product classification. OECD Science, Technology and Industry Working Papers, 26 pp. Accessed 8 March 2014.

Haus-Reve, S., Fitjar, R.D., Rodríguez-Pose, A., 2019. Does combining different types of collaboration always benefit firms? Collaboration, complementarity and product innovation in Norway. Research Policy 48 (6), 1476–1486.

Heidenreich, M., 2009. Innovation patterns and location of European low-and medium-technology industries. Research Policy 38 (3), 483–494.

Hervas-Oliver, J.-L., Albors-Garrigos, J., Baixauli, J.-J., 2012. Beyond R&D activities: The determinants of firms' absorptive capacity explaining the access to scientific institutes in low-medium-tech contexts. Economics of Innovation and New Technology 21 (1), 55–81.

Hervas-Oliver, J.-L., Albors-Garrigos, J., Gil-Pechuan, I., 2011. Making sense of innovation by R&D and non-R&D innovators in low technology contexts: A forgotten lesson for policymakers. Technovation 31 (9), 427–446.

Hirsch-Kreinsen, H., 2008. “Low-Tech” Innovations. Industry and Innovation 15 (1), 19–43.

Hirsch-Kreinsen, H., 2015. Innovation in Low-Tech Industries: Current Conditions and Future Prospects, in: Som, O., Kirner, E. (Eds.), Low-tech Innovation. Competitiveness of the German Manufacturing Sector. Springer International Publishing, pp. 17–32.

Hirsch-Kreinsen, H., Jacobson, D. (Eds.), 2008. Innovation in low-tech firms and industries. Edward Elgar Publishing.

Horvat, D., 2015. Absorptive Capacity in auswärtigen Niederlassungen multinationaler Unternehmen: Eine vergleichende Analyse der Wissensabsorptionsprozesse zweier Unternehmen aus der Antriebstechnik. Kovač, Hamburg, XVII, 272 S.

Horvat, D., Dreher, C., Som, O., 2018. How firms absorb external knowledge - modelling and managing the absorptive capacity process. International Journal of Innovation Management Vol. 23, No. 01, 1950041 (2019).

Huang, C., Arundel, A., Hollanders, H., 2010. How firms innovate: R&D, non-R&D, and technology adoption. Working Paper Series. United Nations University - Maastricht Economic and social Research and training centre on Innovation and Technology.

Jäger, A., Maloca, S., 2016. Dokumentation der Umfrage Modernisierung der Produktion 2015. Karlsruhe: Fraunhofer ISI.

Jansen, J.J.P., Van Den Bosch, F.A.J., Volberda, H.W., 2005. Managing potential and realized absorptive capacity: How do organizational antecedents matter? Academy of Management Journal 48 (6), 999–1015.

Jantunen, A., Ellonen, H.-K., Johansson, A., 2012. Beyond appearances – Do dynamic capabilities of innovative firms actually differ? European Management Journal 30 (2), 141–155.

Jensen, M.B., Johnson, B., Lorenz, E., Lundvall, B.Å., 2007. Forms of knowledge and modes of innovation. Research Policy 36 (5), 680–693.

Jick, T.D., 1979. Mixing qualitative and quantitative methods: Triangulation in action. Administrative Science Quarterly 24 (4), 602–611.

Jiménez-Barrionuevo, M.M., García-Morales, V.J., Molina, L.M., 2011. Validation of an instrument to measure absorptive capacity. Technovation 31 (5), 190–202.

Jones, O., 2006. Developing absorptive capacity in mature organizations: The change agent's role. Management Learning 37 (3), 355–376.

Jong, J.P.J. de, Freel, M., 2010. Absorptive capacity and the reach of collaboration in high technology small firms. Research Policy 39 (1), 47–54.

Jong, J.P.J. de, Marsili, O., 2006. The fruit flies of innovations: A taxonomy of innovative small firms. Research Policy 35 (2), 213–229.

Kastelli, I., Tsakanikas, A., Caloghirou, Y., 2018. Technology transfer as a mechanism for dynamic transformation in the food sector. The Journal of Technology Transfer 43 (4), 882–900.

Katila, R., Ahuja, G., 2002. Something old, something new: A longitudinal study of search behavior and new product introduction. Academy of Management Journal 45 (6), 1183–1194.

Kirner, E., Kinkel, S., Jäger, A., 2009. Innovation paths and the innovation performance of low-technology firms—An empirical analysis of German industry. Research Policy 38 (3), 447–458.

Kirner, E., Som, O., Jäger, A., 2015. Innovation Strategies and Patterns of Non-R&D-Performing and Non-R&D-Intensive Firms, in: Som, O., Kirner, E. (Eds.), Low-tech Innovation. Competitiveness of the German Manufacturing Sector. Springer International Publishing, pp. 91–111.

Koehler, C., Sofka, W., Grimpe, C., 2012. Selective search, sectoral patterns, and the impact on product innovation performance. Research Policy 41 (8), 1344–1356.

Kogut, B., Zander, U., 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. Organization Science 3 (3), 383–397.

Kotabe, M., Jiang, C.X., Murray, J.Y., 2011. Managerial ties, knowledge acquisition, realized absorptive capacity and new product market performance of emerging multinational companies: A case of China. Journal of World Business 46 (2), 166–176.

Lam, A., 2000. Tacit knowledge, organizational learning and societal institutions: An integrated framework. Organization Studies 21 (3), 487–513.

Lane, P.J., Koka, B.R., Pathak, S., 2006. The reification of absorptive capacity: A critical review and rejuvenation of the construct. Academy of Management Review 31 (4), 833–863.

Lane, P.J., Lubatkin, M., 1998. Relative absorptive capacity and interorganizational learning. Strategic Management Journal 19 (5), 461–477.

Lane, P.J., Salk, J.E., Lyles, M.A., 2001. Absorptive capacity, learning, and performance in international joint ventures. Strategic Management Journal 22 (12), 1139–1161.

Laursen, K., 2012. Keep searching and you'll find: What do we know about variety creation through firms' search activities for innovation? Industrial and Corporate Change 21 (5), 1181–1220.

Laursen, K., Salter, A., 2006. Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. Strategic Management Journal 27 (2), 131–150.

Lee, S., Park, G., Yoon, B., Park, J., 2010. Open innovation in SMEs—An intermediated network model. Research Policy 39 (2), 290–300.

Lee, Y.-N., Walsh, J.P., 2016. Inventing while you work: Knowledge, non-R&D learning and innovation. Research Policy 45 (1), 345–359.

Legler, H., Frietsch, R., 2007. Neuabgrenzung der Wissenswirtschaft: forschungsintensive Industrien und wissensintensive Dienstleistungen (NIW/ISI-Listen 2006). Studien zum deutschen Innovationssystem Nr. 22-2007.

Leiponen, A., Drejer, I., 2007. What exactly are technological regimes? Intra-industry heterogeneity in the organization of innovation activities. Research Policy 36 (8), 1221–1238.

Leiponen, A., Helfat, C.E., 2010. Innovation objectives, knowledge sources, and the benefits of breadth. Strategic Management Journal 31 (2), 224–236.

Lenox, M., King, A., 2004. Prospects for developing absorptive capacity through internal information provision. Strategic Management Journal 25 (4), 331–345.

Lewin, A.Y., Massini, S., Peeters, C., 2011. Microfoundations of internal and external absorptive capacity routines. Organization Science 22 (1), 81–98.

Lowik, S., Kraaijenbrink, J., Groen, A.J., 2017. Antecedents and effects of individual absorptive capacity: A micro-foundational perspective on open innovation. Journal of knowledge management 21 (6), 1319–1341.

Lundvall, B., Johnson, B., 1994. The learning economy. Journal of industry studies 1 (2), 23–42.

Marabelli, M., Newell, S., 2014. Knowing, power and materiality: A critical review and reconceptualization of absorptive capacity. International Journal of Management Reviews.

Martinkenaite, I., Breunig, K.J., 2016. The emergence of absorptive capacity through micro–macro level interactions. Journal of Business Research 69 (2), 700–708.

Matusik, S.F., Heeley, M.B., 2005. Absorptive capacity in the software industry: Identifying dimensions that affect knowledge and knowledge creation activities. Journal of Management 31 (4), 549–572.

Mayring, P., 2017. Qualitative Content Analysis. Grundlagen und Techniken, 12., überarbeitete Auflage ed. Beltz.

Mendonça, S., 2009. Brave old world: Accounting for ‘high-tech’ knowledge in ‘low-tech’ industries. Special Issue: Innovation in Low-and Meduim-Technology Industries 38 (3), 470–482.

Miles, J., Gilbert, P., 2005. A handbook of research methods for clinical and health psychology. Oxford University Press on Demand.

Miles, M.B., Huberman, A.M., Saldaña, J., 2014. Qualitative data analysis: A methods sourcebook. Sage.

Minbaeva, D., Pedersen, T., Björkman, I., Fey, C.F., Park, H.J., 2003. MNC knowledge transfer, subsidiary absorptive capacity, and HRM. Journal of International Business Studies 34 (6), 586–599.

Minbaeva, D.B., Pedersen, T., Björkman, I., Fey, C.F., 2014. A retrospective on: MNC knowledge transfer, subsidiary absorptive capacity, and HRM. Journal of International Business Studies 45 (1), 52–62.

Moilanen, M., Østbye, S., Woll, K., 2014. Non-R&D SMEs: external knowledge, absorptive capacity and product innovation. Small Business Economics 43 (2), 447–462.

Morgan, T., Obal, M., Anokhin, S., 2018. Customer participation and new product performance: Towards the understanding of the mechanisms and key contingencies. Research Policy 47 (2), 498–510.

Mowery, D.C., Oxley, J.E., Silverman, B.S., 1996. Strategic alliances and interfirm knowledge transfer. Strategic Management Journal 17 (SUPPL. WINTER), 77–91.

Murovec, N., Prodan, I., 2009. Absorptive capacity, its determinants, and influence on innovation output: Cross-cultural validation of the structural model. Technovation 29 (12), 859–872.

Muscio, A., 2007. The impact of absorptive capacity on SMEs' collaboration. Economics of Innovation and New Technology 16 (8), 653–668.

Nelson, R., Winter, S., 1982. An Evolutionary Theory of Economic Change. Harvard University Press, Cambridge, MA.

Nelson, R.R., 1991. Why do firms differ, and how does it matter? Strategic Management Journal 12 (S2), 61–74.

Nicolini, D., 2009. Zooming in and out: Studying practices by switching theoretical lenses and trailing connections. Organization Studies 30 (12), 1391–1418.

OECD, 1994. Science and Technology Policy: Review and Outlook. OECD Publications, Paris.

OECD, 2005. Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data. OECD Publishing.

Ortega-Argilés, R., Vivarelli, M., Voigt, P., 2009. R&D in SMEs: a paradox? Small Business Economics 33 (1), 3–11.

Parrilli, M.D., Balavac, M., Radicic, D., 2020. Business innovation modes and their impact on innovation outputs: Regional variations and the nature of innovation across EU regions. Research Policy 49 (8), 104047.

Parrilli, M.D., Heras, H.A., 2016. STI and DUI innovation modes: Scientific-technological and context-specific nuances. Research Policy 45 (4), 747–756.

Parrilli, M.D., Radicic, D., 2021. STI and DUI innovation modes in micro-, small-, medium-and large-sized firms: distinctive patterns across Europe and the US. European Planning Studies 29 (2), 346–368.

Patterson, W., Ambrosini, V., 2015. Configuring absorptive capacity as a key process for research intensive firms. Technovation 36–37, 77–89.

Patton, M.Q., 1990. Qualitative evaluation and research methods. SAGE Publications, inc.

Pavitt, K., 1984. Sectoral patterns of technical change: Towards a taxonomy and a theory. Research Policy 13 (6), 343–373.

Peneder, M., 2010. Technological regimes and the variety of innovation behaviour: Creating integrated taxonomies of firms and sectors. Research Policy 39 (3), 323–334.

Peteraf, M.A., 1993. The cornerstones of competitive advantage: A resource-based view. Strategic Management Journal 14 (3), 179–191.

Porter, M.E., 1996. What is strategy? Harvard Business Review 74 (6), 61–78.

Prahalad, C.K., Hamel, G., 1990. The Core Competence of the Corporation. Harvard Business Review 68 (3), 79-91.

Rammer, C., Czarnitzki, D., Spielkamp, A., 2009. Innovation success of non-R&D-performers: Substituting technology by management in SMEs. Small Business Economics 33 (1), 35–58.

Rammer, C., Köhler, C., Murmann, M., Pesau, A., Schwiebacher, F., Kinkel, S., Kirner, E., Schubert, T., Som, O., 2011. Innovationen ohne Forschung und Entwicklung: Eine Untersuchung zu Unternehmen, die ohne eigene FuE-Tätigkeit neue Produkte und Prozesse einführen. Studien zum deutschen Innovationssystem Nr. 15-2011, Mannheim und Karlsruhe.

Ritter, T., Gemünden, H.G., 2004. The impact of a company's business strategy on its technological competence, network competence and innovation success. Journal of Business Research 57 (5), 548–556.

Robertson, P.L., Casali, G.L., Jacobson, D., 2012. Managing open incremental process innovation: Absorptive Capacity and distributed learning. Research Policy 41 (5), 822–832.

Rothaermel, F.T., Alexandre, M.T., 2009. Ambidexterity in technology sourcing: The moderating role of absorptive capacity. Organization Science 20 (4), 759–780.

Rowley, J., 2012. Conducting research interviews. Management Research Review 35 (3/4), 260–271.

Santamaría, L., Nieto, M.J., Barge-Gil, A., 2009. Beyond formal R&D: Taking advantage of other sources of innovation in low- and medium-technology industries. Research Policy 38 (3), 507–517.

Schmidt, T., 2005. Absorptive Capacity - one size fits all? A firm-level analysis of absorptive capacity for different kinds of knowledge. ZEW Discussion Papers, No. 05-72.

Schmidt, T., 2010. Absorptive capacity—one size fits all? A firm-level analysis of absorptive capacity for different kinds of knowledge. Managerial and Decision Economics 31 (1), 1–18.

Schmiedeberg, C., 2008. Complementarities of innovation activities: An empirical analysis of the German manufacturing sector. Research Policy 37 (9), 1492–1503.

Schweisfurth, T.G., Raasch, C., 2018. Absorptive capacity for need knowledge: Antecedents and effects for employee innovativeness. Research Policy 47 (4), 687–699.

Seawright, J., Gerring, J., 2008. Case selection techniques in case study research: A menu of qualitative and quantitative options. Political Research Quarterly 61 (2), 294–308.

Sirmon, D.G., Hitt, M.A., Ireland, R.D., Gilbert, B.A., 2011. Resource orchestration to create competitive advantage: Breadth, depth, and life cycle effects. Journal of Management 37 (5), 1390–1412.

Sjodin, D., Frishammar, J., Thorgren, S., 2019. How Individuals Engage in the Absorption of New External Knowledge: A Process Model of Absorptive Capacity. Journal of Product Innovation Management 36 (3), 356–380.

Sofka, W., Grimpe, C., 2010. Specialized search and innovation performance–evidence across Europe. R&D Management 40 (3), 310–323.

Som, O., 2012. Innovation without R&D: Heterogeneous innovation patterns of non-R&D-performing firms in the German manufacturing industry. Springer Gabler, Wiesbaden, 1 online resource (xviii, 461.

Som, O., Kirner, E., 2015. Introduction, in: Som, O., Kirner, E. (Eds.), Low-tech Innovation. Competitiveness of the German Manufacturing Sector. Springer International Publishing, pp. 1–15.

Som, O., Kirner, E., Jäger, A., 2013. Absorptive capacity of non-R&D-intensive firms in the German Manufacturing industry. 35th DRUID Celebration Conference.

Song, Y., Gnyawali, D.R., Srivastava, M.K., Asgari, E., 2018. In Search of Precision in Absorptive Capacity Research: A Synthesis of the Literature and Consolidation of Findings. Journal of Management 44 (6), 2343–2374.

Spithoven, A., Clarysse, B., Knockaert, M., 2011. Building absorptive capacity to organise inbound open innovation in traditional industries. Technovation 31 (1), 10–21.

Spithoven, A., Vanhaverbeke, W., Roijakkers, N., 2013. Open innovation practices in SMEs and large enterprises. Small Business Economics 41 (3), 537–562.

Srholec, M., Verspagen, B., 2008. The voyage of the beagle in innovation systems land: Explorations on sectors, innovation, heterogeneity and selection. UNU-MERIT.

Steckler, A., McLeroy, K.R., Goodman, R.M., Bird, S.T., McCormick, L., 1992. Toward integrating qualitative and quantitative methods: an introduction. Sage Publications Sage CA: Thousand Oaks, CA.

Straus, A., Corbin, J., 1998. Basics of qualitative research: Techniques and procedures for developing grounded theory. Thousand Oaks, CA: Sage.

Sun, P.Y.T., Anderson, M.H., 2010. An examination of the relationship between absorptive capacity and organizational learning, and a proposed integration. International Journal of Management Reviews 12 (2), 130–150.

Teddlie, C., Yu, F., 2007. Mixed methods sampling: A typology with examples. Journal of mixed methods research 1 (1), 77–100.

Teece, D.J., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strategic Management Journal 18 (7), 509–533.

Teirlinck, P., Spithoven, A., 2013. Research collaboration and R&D outsourcing: Different R&D personnel requirements in SMEs. Technovation 33 (4), 142–153.

Ter Wal, A.L.J., Criscuolo, P., Salter, A., 2017. Making a marriage of materials: The role of gatekeepers and shepherds in the absorption of external knowledge and innovation performance. Research Policy 46 (5), 1039–1054.

Terjesen, S., Patel, P.C., 2017. In search of process innovations: The role of search depth, search breadth, and the industry environment. Journal of Management 43 (5), 1421–1446.

Thomä, J., Zimmermann, V., 2020. Interactive learning—The key to innovation in non-R&D-intensive SMEs? A cluster analysis approach. Journal of Small Business Management 58 (4), 747–776.

Todorova, G., Durisin, B., 2007. Absorptive capacity: Valuing a reconceptualization. Academy of Management Review 32 (3), 774–786.

Tsai, W., 2001. Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance. Academy of Management Journal 44 (5), 996–1004.

Tunzelmann, N. von, Acha, V., 2005. Innovation in “low-tech” industries, in: Fagerberg, J., Mowery, D.C., Nelson, R.R. (Eds.), The Oxford Handbook of Innovation. Oxford Handbooks Online, pp. 407–432.

Van de Vrande, V., de Jong, J. P.J., Vanhaverbeke, W., Rochemont, M. de, 2009. Open innovation in SMEs: Trends, motives and management challenges. Technovation 29 (6), 423–437.

Van de Vrande, V., Vanhaverbeke, W., Gassmann, O., 2010. Broadening the scope of open innovation: past research, current state and future directions. International Journal of Technology Management 52 (3/4), 221–235.

Van Den Bosch, F.A.J., van Wijk, R., Volberda, H.W., 2003. Absorptive capacity: Antecedents, models and outcomes. Erasmus Research Institute of Management (ERIM).

Van Den Bosch, F.A.J., Volberda, H.W., Boer, M. de, 1999. Coevolution of firm absorptive capacity and knowledge environment: Organizational forms and combinative capabilities. Organization Science 10 (5), 551–568.

van Wijk, R., Van Den Bosch, F.A.J., Volberda, H.W., 2011. Absorptive capacity: taking stock of its progress and prospects, in: Easterby-Smith, M., Lyles, M.A. (Eds.), Handbook of Organizational Learning and Knowledge Management. Chichester: Wiley, pp. 273–304.

Vanhaverbeke, W., Chesbrough, H., West, J., 2014. Surfing the new wave of open innovation research, in: Chesbrough, H., Vanhaverbeke, W., West, J. (Eds.), New frontiers in open innovation. Oxford University Press, pp. 281–294.

Vega-Jurado, J., Gutiérrez-Gracia, A., Fernández-de-Lucio, I., 2008. Analyzing the determinants of firm's absorptive capacity: Beyond R&D. R&D Management 38 (4), 392–405.

Venkatraman, N., Grant, J.H., 1986. Construct measurement in organizational strategy research: A critique and proposal. Academy of Management Review 11 (1), 71–87.

Vera, D., Crossan, M., Apaydin, M., 2011. A framework for integrating organizational learning, knowledge, capabilities, and absorptive capacity, in: Easterby-Smith, M., Lyles, M.A. (Eds.), Handbook of organizational learning and knowledge management. John Wiley & Sons, pp. 153–180.

Veugelers, R., 1997. Internal R&D expenditures and external technology sourcing. Research Policy 26 (3), 303–315.

Volberda, H.W., Foss, N.J., Lyles, M.A., 2010. Absorbing the concept of absorptive capacity: How to realize its potential in the organization field. Organization Science 21 (4), 931–951.

Wagner, R., 2012. Kooperative Technologieentwicklung - Eine Mehrebenenanalyse von Absorptive Capacity Praktiken. Kölner Wissenschaftsverlag.

Weidner, N., 2020. Exploring absorptive capacity in non-R&D innovative firms: The interplay between individuals and organisational practices. Conference proceedings

of DRUID Academy Conference 2020 at University of Southern Denmark, Odense, Denmark January 16-17, 2020.

Weidner, N., Som, O., 2015. How open is" low-tech innovation"? Empirical insights from German manufacturing industry. ISPIM Conference Proceedings.

Wernerfelt, B., 1995. The resource-based view of the firm: Ten years after. Strategic Management Journal 16 (3), 171–174.

West, J., Bogers, M., 2014. Leveraging external sources of innovation: a review of research on open innovation. Journal of Product Innovation Management 31 (4), 814–831.

West, J., Bogers, M., 2017. Open innovation: Current status and research opportunities. Innovation: Management, Policy & Practice 19 (1), 43–50.

Whetten, D.A., 1989. What constitutes a theoretical contribution? Academy of Management Review 14 (4), 490–495.

Yao, F.K., Chang, S., 2017. Do Individual Employees' Learning Goal Orientation and Civic Virtue Matter? A Micro-Foundations Perspective on Firm Absorptive Capacity. Strategic Management Journal 38 (10), 2041–2060.

Yin, R.K., 2006. Case study research: Design and methods, Third Edition ed. Sage publications.

Yin, R.K., 2009. Case study research: Design and methods, Fourth Edition ed. Sage publications.

Zahra, S.A., George, G., 2002. Absorptive capacity: A review, reconceptualization, and extension. Academy of Management Review 27 (2), 185–203.

Zajac, E.J., Kraatz, M.S., Bresser, R.K.F., 2000. Modeling the dynamics of strategic fit: A normative approach to strategic change. Strategic Management Journal 21 (4), 429–453.

Zobel, A.-K., 2017. Benefiting from open innovation: A multidimensional model of absorptive capacity. Journal of Product Innovation Management 34 (3), 269–288.

Zou, T., Ertug, G., George, G., 2018. The capacity to innovate: A meta-analysis of absorptive capacity. Innovation: Management, Policy & Practice 20 (2), 87–121.

## ERKLÄRUNG GEM. § 10 ABS. 3

Hiermit erkläre ich, dass ich für die Dissertation folgende Hilfsmittel und Hilfen verwendet habe:

- Software: Microsoft Word, Excel, PowerPoint, SPSS, Citavi und MAXQDA
- Literatur (siehe Literaturverzeichnis).
- Bei den verwendeten Daten handelt es sich um
  (a) die Daten aus der Erhebung Modernisierung der Produktion 2015, für deren Nutzung und Veröffentlichung der daraus entstandenen Forschungsergebnisse ich eine Einwilligung vom Fraunhofer-Institut für System- und Innovationsforschung ISI erhalten habe;
  (b) die Daten aus den halbstrukturierten Interviews mit vier Unternehmen aus dem Deutschen Verarbeitenden Gewerbe. Für die Erhebung und Verarbeitung personenbezogener Interviewdaten sowie ihre Archivierung in anonymisierter Form habe ich die Einwilligung der teilnehmenden Interviewpartner.

Auf dieser Grundlage habe ich die Arbeit selbstständig verfasst.

Nadia Weidner

Karlsruhe, November 2021