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CAPABILITIES FOR STRATEGIC ADAPTATION: MICRO-FOUNDATIONS, ORGANIZATIONAL CONDITIONS, AND PERFORMANCE IMPLICATIONS

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Andreas Philipp Distel

CAPABILITIES FOR STRATEGIC ADAPTATION:

**MICRO-FOUNDATIONS, ORGANIZATIONAL
CONDITIONS, AND PERFORMANCE
IMPLICATIONS**

The PhD School of Economics and Management

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CBS  **COPENHAGEN BUSINESS SCHOOL**
HANDELSHØJSKOLEN

Capabilities for Strategic Adaptation

*Micro-Foundations, Organizational Conditions,
and Performance Implications*

Andreas Philipp Distel

Dissertation

submitted for the degree of
Doctor of Philosophy (Ph.D.)

Supervisor: Professor Nicolai J. Foss

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English Summary

This dissertation explores capabilities that enable firms to strategically adapt to environmental changes and preserve competitiveness over time – often referred to as dynamic capabilities. While dynamic capabilities being a popular research domain, too little is known about what these capabilities are in terms of their constituent elements, where these capabilities come from, and how their effectiveness can be fostered. Thus, the dissertation's aim is to address these gaps by advancing our understanding of the multilevel aspects and micro-foundations of dynamic capabilities. In doing so, it focuses on capabilities for sensing and seizing new business opportunities and reconfiguring corporate resources. More specifically, the dissertation examines the role of key organization members, such as knowledge workers and top managers, in defining and building these capabilities. Moreover, it investigates how organizational conditions, such as organizational design, support the emergence and performance of such capabilities.

In detail, the dissertation consists of three self-contained research papers. The first paper is a systematic, multilevel review of the innovation literature; it reinterprets evidence from prior empirical studies through the dynamic capabilities lens and develops propositions for future research. The second paper is an empirical study on the origins of firm-level absorptive capacity; it explores how organization-level antecedents, through their impact on individual-level antecedents, influence firms' ability to absorb and leverage new knowledge. The third paper is an empirical study which conceptualizes top managers' resource cognition as a managerial capability underlying firms' resource adaptation; it empirically examines the performance implications of this capability and organizational contingencies affecting the capability-performance link. Taken together, the dissertation develops new insights into the nature, origins, and management of dynamic capabilities and opens up the black box of what enables firms to strategically adapt.

Dansk Resumé

Denne afhandling undersøger de *capabilities*, som sætter virksomheder i stand til at strategisk tilpasse sig et omskiftelig miljø og fastholde konkurrenceevnen over tid - ofte betegnet *dynamic capabilities*. Selvom *dynamic capabilities* er et populært forskningsområde ved vi fortsat ikke tilstrækkeligt om de elementer de udgøres af, deres ophav, og hvorledes deres effektivitet kan fremmes. Afhandlingens formål er således at afhjælpe disse mangler ved at fremme vores forståelse af hvorledes aspekter fra flere forskellige analyseniveauer udgør *dynamic capabilities*. Særligt fokus er på virksomheders evne til at opdage og udnytte muligheder og skabe nye ressourcekonfigurationer. Konkret undersøger afhandlingen den rolle som organisationens nøglemedarbejdere, såsom vidensarbejdere og topledere, spiller i udviklingen af *dynamic capabilities*. Derudover undersøges påvirkningen fra organisatoriske faktorer, såsom organisations design, for fremkomsten og effektiviteten af disse *dynamic capabilities*.

Afhandlingen består af tre selvstændige forskningsartikler. Den første artikel er en systematisk gennemgang af innovationslitteraturen. Artiklen fortolker tidligere empiriske studier i et *dynamic capabilities* perspektiv og angiver retninger for fremtidig forskning. Den anden artikel er en empirisk undersøgelse af grundlaget for virksomheders *absorptive capacity*. Artiklen undersøger hvorledes organisatoriske faktorer, gennem deres påvirkning af individer, har betydning for virksomheders evner til at absorbere og anvende ny viden. Den tredje artikel er en empirisk undersøgelse, der konceptualiserer topledernes ressourcebevidsthed som en *managerial capability*, der understøtter virksomheders evne til at tilpasse sine ressourcer. Empirisk undersøges betydningen for virksomhedens *performance*, samt hvorledes denne effekt påvirkes af organisatoriske faktorer. Samlet set udvikler afhandlingen ny viden om beskaffenheden af, ophavet til, og ledelsen af *dynamic capabilities*.

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Andreas Distel
Copenhagen, 2016

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Chapter 1

Introduction

1.1 PURPOSE OF THE DISSERTATION

Practitioners and researchers in strategic management have long dealt with the fundamental question of how firms can attain competitive advantages. A prominent view addressing this question that has emerged over the last three decades in strategy research and organization theory is the capabilities-based approach (Amit & Schoemaker, 1993; Collis, 1994; Dosi, Nelson, & Winter, 2000; Helfat & Winter, 2011; Kogut & Zander, 1992; Nelson & Winter, 1982). This view portrays firms as repositories of organizational capabilities, broadly defined as “the capabilities of an enterprise to organize, manage, coordinate or govern sets of activities”(Dosi & Teece, 1998: 284) and understood as a special way an organization can draw upon to allocate resources (Schreyögg & Kliesch-Eberl, 2007). Differences in such capabilities have been proposed to explain heterogeneity in performance among firms (Amit & Schoemaker, 1993; Peteraf & Barney, 2003). For instance, Toyota’s success compared to other mass automobile manufacturers may be attributable to the firm’s better capabilities in producing cars and Walmart’s superior position within the retailing business may be explained by its superior logistics capabilities (Helfat & Peteraf, 2003).

To explain how capabilities provide superior firm performance over time and why some firms can survive in fast-moving markets while others fail, researchers have increasingly emphasized so-called *dynamic* capabilities (Eisenhardt & Martin, 2000; Moliterno & Wiersema, 2007; Teece, Pisano, & Shuen, 1997; Zahra, Sapienza, & Davidsson, 2006). A dynamic capability refers to the “capacity of an organization to purposefully create, extend, or modify its resource base” (Helfat et al., 2007: 4) and by adding the adjective dynamic it can be regarded as a sort of organizational capability to manage continuous, strategic adaptation of a firm’s resources, allowing it to cope with changing environments (Ambrosini & Bowman, 2009). IBM, for example, has successfully adapted itself several times, most recently transforming from a

hardware producer to an information technology-based business services provider (Agarwal & Helfat, 2009). This success has been attributed to the firm's dynamic capabilities to identify market shifts and emerging technologies and to address new challenges by implementing new business initiatives or even by reconfiguring its resources and structures (Harreld, O'Reilly III, & Tushman, 2007).

Although the dynamic capabilities approach is practically relevant and has attracted the interest of many scholars (Barreto, 2010; Peteraf, Di Stefano, & Verona, 2013), this research domain has also been the subject of criticism (e.g., Arend & Bromiley, 2009). Specifically, the limited progress regarding empirical studies on dynamic capabilities has left the field with some conceptual confusion and underexplored issues (Di Stefano, Peteraf, & Verona, 2014; Peteraf et al., 2013). While researchers have primarily emphasized and studied the relevance of dynamic capabilities for firm-level outcomes, such as firm performance, innovativeness, competitive advantage, and adaptability to environmental changes, we still lack a sound understanding of the nature, origins, and management of such capabilities (Di Stefano et al., 2014; Felin, Foss, Heimeriks, & Madsen, 2012; Kraatz & Zajac, 2001; Zollo & Winter, 2002); in other words, we do not sufficiently know:

- What are dynamic capabilities?
- Where do they come from?
- How can they be formed and how can their effectiveness be fostered?

A key reason why these questions have remained largely unanswered is that most of the extant research has disregarded the multilevel aspects of dynamic capabilities (Rothaermel & Hess, 2007), although capabilities, as most management phenomena, comprise socially complex behaviors (Collis, 1994) and, thus, are inherently multilevel (Hitt, Beamish, Jackson, & Mathieu, 2007). Notably, we still have a relative lack of understanding of what capabilities are in the first place in terms of their constituent elements at different levels of analysis (Salvato & Rerup, 2011). Moreover, we are deficient in knowledge of how these capabilities emerge from micro-level foundations, that is, from the actions and characteristics of a firm's individual members (Felin, Foss, & Ployhart, 2015), in combination with the macro-level context to which individuals are exposed, such as organizational design (Barney & Felin, 2013).

In the case of IBM, for example, the firm's ability to develop from a hardware manufacturer to an integrated services company was certainly first and foremost due to one

central individual, former chief executive officer (CEO) Lou Gerstner, and his ability to sense and judge new business opportunities. As Gerstner foresaw in the mid-1990s, “[o]ver the next decade, customers would increasingly value [...] solutions that integrated technology from various suppliers” (Gerstner Jr., 2002: 123). However, it is highly questionable whether Gerstner’s vision and ideas would have materialized into IBM’s successful transformation without favoring conditions and structural changes at the organizational level (Helfat & Peteraf, 2015).

Similarly, firms that are more capable than others in leveraging new external information to improve their innovativeness may be better equipped with highly skilled knowledge workers who acquire and translate external knowledge into something that their company can use (Tushman, 1977; Tushman & Katz, 1980). Yet, these firms might not only be dependent on the specific abilities of their knowledge workers, but also need the right organizational mechanisms and incentives to nurture the behaviors of these individuals. In short, exploring of what dynamic capabilities constitute, how differences in the abilities and actions of certain individuals account for their heterogeneity, and how these individuals are affected by organization-level conditions they face may offer fruitful insights into the nature, building, and efficacy of capabilities (Felin & Foss, 2005; Felin et al., 2012; Gavetti, 2005).

Therefore, the overall purpose of this dissertation is to contribute to a better understanding of the multilevel aspects of dynamic capabilities including their micro-foundations. Specifically, the dissertation investigates the role that key organization members, such as core knowledge workers and top managers, and their characteristics play in defining and forming specific dynamic capabilities, such as firm-level absorptive capacity and managerial-level cognitive capability. Moreover, the dissertation examines how the organizational context influences the emergence and effectiveness of such capabilities.

The remainder of this introductory chapter is structured as followed. In the next section, I will embed the dissertation into the larger context of the capabilities-based literature by reviewing the theoretical background and important definitions. I will also elaborate on essential critiques of the capabilities approach which are subsumed under overall research questions that serve as overarching guide for this dissertation. Then, I will provide an overview of the three research papers which build the main part of this dissertation. Moreover, I will present the research process undertaken in this dissertation with a brief description of the different methods and datasets used.

1.2 RESEARCH CONTEXT OF THE DISSERTATION

Theoretical Background and Definitions

The notion of organizational and dynamic capabilities is based on the resource-based view (RBV) of the firm (Barney, 1991; Wernerfelt, 1984) and has its roots in the ‘routines’ construct of Nelson and Winter’s (1982) evolutionary economics perspective. *Organizational routines* are conceptualized in Nelson and Winter metaphorically as the organization-level counterparts of individual-level skills (cf. Felin & Foss, 2009); they have been broadly described as “collective recurrent activity patterns” (Becker, 2004: 645) and reflect learned behavior of an organization for repeated performance triggered by certain internal or external stimuli (Cohen & Bacdayan, 1994; Cohen et al., 1996; Zollo & Winter, 2002).

The routine construct has strongly informed the theoretical development of *organizational capabilities* (Felin & Foss, 2009), which are similar to routines in that they also represent collective, patterned, and learned action and can be executed repetitiously (Salvato & Rerup, 2011; Winter, 2003). Nonetheless, organizational capabilities are distinct from routines as they are conceptualized at a higher level of abstraction as so-called higher order routines or collections of routines that are designated to perform functional tasks (Amit & Schoemaker, 1993; Dosi et al., 2000; Felin et al., 2012; Salvato & Rerup, 2011; Winter, 2003). Consequently, organizational capabilities are also defined as “the socially complex routines that determine the efficiency with which firms physically transform inputs into outputs” (Collis, 1994: 154).

In the context of the RBV, organizational capabilities are similar to *resources* in that both are assumed to be heterogeneously distributed across companies (Barney, 1991) and can provide sustained competitive advantages (Barreto, 2010). However, resources and organizational capabilities also differ in their specific meaning: While the former are “stocks of available factors that are owned or controlled by the firm,” the latter correspond to “a firm’s capacity to deploy resources, usually in combination, using organizational processes, to effect a desired end” (Amit & Schoemaker, 1993: 35; as also cited in Barreto, 2010: 258).

The RBV including the notion of organizational capabilities, however, has been criticized for being too static (Priem & Butler, 2001) because it does not really consider how firms can generate new resources and renew their current resource base to cope with technological, market, and other significant external changes (Ambrosini & Bowman, 2009; Barreto, 2010). Thus, the RBV is limited in explaining how firms can attain competitive advantages in shifting

environments over time. To overcome this major limitation, Teece and colleagues introduced the notion of *dynamic capabilities* as special organizational capabilities extending the RBV (Teece & Pisano, 1994; Teece et al., 1997). In their foundational article, the authors defined dynamic capabilities as “the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments” (Teece et al., 1997: 516). Other authors have developed the domain further and provided their own definitions by highlighting various crucial features of dynamic capabilities (for an overview see Barreto, 2010).

Dynamic capabilities have been described as abilities (Zahra et al., 2006), capacities (Helfat et al., 2007), processes (Eisenhardt & Martin, 2000), and higher level routines or collections of routines exhibiting “learned and stable patterns of collective activity” (Zollo & Winter, 2002: 340). The deployment of dynamic capabilities is intentional, deliberate, and repeatable (Ambrosini & Bowman, 2009; Helfat et al., 2007; Zahra et al., 2006) and, thus, excludes ad-hoc problem solving (Schreyögg & Kliesch-Eberl, 2007). Concerning their specific role, dynamic capabilities have been distinguished from more general organizational capabilities or so-called ordinary or operational capabilities. While ordinary capabilities accomplish more basic functional activities on an ongoing basis to compete in the present and maintain the status quo (Ambrosini & Bowman, 2009; Helfat & Winter, 2011; Salvato & Rerup, 2011), dynamic capabilities are intended to adapt, renew, create, leverage or transform the resource base, routines, and other capabilities to address the demands of dynamic environments (Schreyögg & Kliesch-Eberl, 2007; Teece, 2007; Teece et al., 1997). Thus, in contrast to ordinary capabilities, dynamic capabilities permit a firm to change how it currently competes (Helfat & Winter, 2011; Winter, 2003).

The literature on dynamic capabilities has offered examples of more specific dynamic capabilities (for further examples see Eisenhardt & Martin, 2000). For instance, new product development processes are considered a dynamic capability through which firms combine different functional activities such as research and development (R&D) and marketing, to develop new products and services in response to market opportunities (Eisenhardt & Martin, 2000; Krishnan & Ulrich, 2001; Lawson & Samson, 2001). Absorptive capacity, a firm’s ability to acquire and exploit knowledge from external sources (in addition to internal knowledge generation), is another example of a dynamic capability because it allows a firm to attain higher innovativeness and strategic flexibility, both of which are crucial for competing in dynamic markets (Lane, Koka, & Pathak, 2006; Zahra & George, 2002).

Also, regarding inter-organizational activities, scholars have revealed more concrete dynamic capabilities. For instance, the acquisition process, including post-acquisition integration, may constitute a dynamic capability because it enables a firm to alter its resource base by integrating new resources from the target firm, modifying or consolidating existing resources or routines in both the acquiring and the target firm to achieve synergies (Karim & Mitchell, 2000; Zollo & Winter, 2002). With a similar intention to access new resources, alliance management capability has been portrayed as a dynamic capability comprising routines to identify alliance partners and to coordinate and ensure learning in ongoing partnerships (Kale, Dyer, & Singh, 2002; Schilke, 2014). In recent years, some scholars have redirected the focal point of dynamic capabilities from the role of the firm to the role of managers (cf. Di Stefano et al., 2014) by introducing the notion of *dynamic managerial capabilities* (Adner & Helfat, 2003; Eggers & Kaplan, 2013). Hence, emphasis is put directly on managers' capabilities for orchestrating resources and on managers' cognition, human capital, and social capital as major underlying factors of such capabilities (Helfat & Martin, 2015; Kor & Mesko, 2013).

In the light of the various examples of dynamic capabilities and in order to integrate the selected capabilities that I address in the following chapters into one overarching framework, I draw on Teece's (2007) disaggregation of dynamic capabilities into three separate clusters. These clusters encompass: (a) *sensing* capabilities which refer to identifying, shaping, and evaluating new business and technological opportunities, (b) *seizing* capabilities which refer to addressing new opportunities by investing in appropriate activities and gaining value from it, and (c) *reconfiguring* capabilities which refer to keeping up growth and competitiveness by constantly orchestrating, recombining, and transforming organizational resources and structures to adapt to market and technological changes (Teece, 2007). I build on Teece's (2007) framework because it serves analytical and applied purposes and offers a comprehensive and structured conception of dynamic capabilities (cf. Helfat & Peteraf, 2015; Teece, 2012; Teece, 2014). For similar reasons, this systematization has been applied in recent articles that elaborate on critical underpinnings of dynamic capabilities (Helfat & Peteraf, 2015; Hodgkinson & Healey, 2011; Martin, 2011). In Table 1.1, I further clarify this systematization by giving examples of how different capabilities and their primary focus relate to sensing, seizing, and reconfiguring.

Table 1.1: Systematization of Selected Capabilities within Teece's (2007) Framework

Examples of dynamic capabilities	Definition	Primary relation to...			Further addressed in this dissertation?
		<i>Sensing</i>	<i>Seizing</i>	<i>Reconfiguring</i>	
<i>New product development capability</i>	A firm's ability to transform new opportunities, ideas, and knowledge into new products and services for sale (Krishnan & Ulrich, 2001; Lawson & Samson, 2001).	Research activities to generate new ideas and knowledge (Teece, 2007).	Development and commercialization activities to produce and market new products and services (Teece, 2007).	Rather slightly related	In Chapter 2
<i>Absorptive capacity</i>	A firm's ability "to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990: 128).	Potential absorptive capacity as the acquisition and assimilation of new external knowledge (Zahra & George, 2002).	Realized absorptive capacity as the transformation and exploitation of the acquired knowledge (Zahra & George, 2002).	Rather slightly related	In Chapter 3
<i>Post-acquisition integration capability</i>	A firm's ability "to plan and effectively execute postacquisition integration processes" (Zollo & Winter, 2002: 340).	Not primarily related	Not primarily related	Modification and consolidation of resources and operating routines in the acquiring and target firm (Zollo & Winter, 2002).	Not addressed
<i>Resource divestment capability</i>	"[T]he disposition of an asset from the firm's resource portfolio, and the associated factor market transfer of that resource to another firm in the industry" (Moliterno & Wiersema, 2007: 1065).	Not primarily related	Not primarily related	Divestment of resources as organizational change routine to reconfigure the resource portfolio (Moliterno & Wiersema, 2007).	Not addressed
<i>Managerial resource cognition</i>	A managerial capability as "the identification of resources and the understanding of their fungibility" (Danneels, 2011:21).	Rather slightly related	Rather slightly related	Managers' understanding of corporate resources as critical requirement for their orchestration and reconfiguration (Teece, 2007).	In Chapter 4

Overall Research Questions

In the following, I point out essential critiques that the capabilities approach, and particularly the dynamic capabilities perspective, is facing. Naturally, I will not cover all of the critiques (see Arend & Bromiley, 2009, for an overview of the main concerns), but I will summarize and concentrate on those points of criticism and research gaps which are most meaningful to motivate the purpose of this dissertation. The critiques are organized around three overall research questions (ORQ) that serve as overarching guide for the next chapters.

ORQ 1: What are dynamic capabilities and where are they located (nature and locus)?

The extant research is not clear about the nature of dynamic capabilities and their actual locus within the firm (Di Stefano, Peteraf, & Verona, 2010; Di Stefano et al., 2014). In this regard, the concept has been criticized for its inconsistent and unspecified definitions and its underdeveloped empirical progress (Arend & Bromiley, 2009; Peteraf et al., 2013; Zahra et al., 2006). Specifically, there is little clarity about whether dynamic capabilities reflect *latent* abilities (e.g., Teece et al., 1997) or represent *concrete* organizational processes and routines (e.g., Eisenhardt & Martin, 2000)¹ and about whether they are located solely at the organizational level, as most studies suggest (e.g., Zahra & George, 2002), or appear at lower levels, especially at the managerial level, as some recent work has proposed (e.g., Helfat & Martin, 2015).

In terms of dynamic capabilities as latent abilities, this conceptualization assumes that a dynamic capability is not directly, but rather indirectly, observable; that is, it is observable only after it is called into action (Di Stefano et al., 2014). The main point of criticism here is the post hoc identification of a dynamic capability in empirical studies (Arend & Bromiley, 2009): After a firm was found to have successfully survived one or multiple market changes – or at least to have better coped with changes than its competitors – one may attribute dynamic capabilities to this firm (cf. Williamson, 1999).

In contrast, the definition of dynamic capabilities as concrete organizational processes and routines conceptualizes dynamic capabilities in a more specific, observable manner, making them potentially easier to empirically identify and measure (Di Stefano et al., 2014). However, in this form, dynamic capabilities are described as collective constructs without sufficiently addressing

¹ Dynamic capabilities as latent abilities can be exemplified by the latent capability of a firm's absorptive capacity as described by Zahra and George (2002), whereas dynamic capabilities as concrete processes and routines can be exemplified by well-defined product development routines (e.g., stage-gate process) as proposed by Eisenhardt and Martin (2000).

their constituent, more micro-level elements (Salvato & Rerup, 2011). For example, the question of *who* in the processes and routines conducts *what* activities and *how* often remains unanswered (Argote & Ren, 2012; Felin et al., 2012; Salvato, 2009). With respect to the conceptualization of dynamic capabilities at the managerial level as managerial capabilities to manage resources, this view may better meet recent calls to focus on individual decision-makers (specifically, those who actually carry out activities) and, thus, more realistically reflect how dynamic capabilities are put to use in practice (Helfat & Martin, 2015). Yet, a concern regarding this perspective is that it may not build a theoretical foundation for dynamic capabilities that is as robust as in the organizational perspective, but rather deals with the applicability of the approach in the real business world (Di Stefano et al., 2014).

In sum, whatever conceptualization of dynamic capabilities one may draw upon, each of these views has its deficits and no commonly accepted comprehension of the nature of dynamic capabilities exists (Peteraf et al., 2013). This points to the need for theoretical clarification to progress and empirical testing to proceed to better understand what dynamic capabilities look like and where they are situated.

ORQ 2: Where do dynamic capabilities come from (micro-foundations)?

The central literature on dynamic capabilities has dealt with capabilities as the focal construct for understanding differences in firm-level outcomes such as competitive advantage, discrepancies in firm innovativeness, and heterogeneity in companies' long-term survival (Helfat et al., 2007; Peteraf et al., 2013). Such work has focused on the aim of dynamic capabilities and sought to explain how firms adapt to environmental changes (Eisenhardt & Martin, 2000; Teece et al., 1997), without establishing a more profound understanding of the origins of those capabilities (cf. Felin & Foss, 2009). As Collis (1994: 144) emphasized in a critical research note on capabilities, "they are certainly not the 'ultimate' source [of competitive advantage]" and, thus, it seems problematic to only elaborate on the construct's impact on performance consequences, while neglecting its endogenous nature.

Some scholars have considered prior experience, especially past routines and capabilities, as the origin of current and future capabilities (Eisenhardt & Martin, 2000; King & Tucci, 2002; Nelson & Winter, 1982). For instance, a firm's experience with managing alliances in the past may explain its success in managing future alliances. One may infer from this observation that the firm possesses an alliance management capability. Yet, such reasoning has been criticized for

potentially causing an infinite regress and for not really addressing where path-dependent behavior or learning originally starts (Collis, 1994; Felin & Foss, 2009). Another problem with prior experience as an antecedent is that it may contradict the idea of a “dynamic” capability because experience leads to higher stability and lock-in over time and can constrain a firm’s adaptability (Schreyögg & Kliesch-Eberl, 2007). Other work has proposed that organizational antecedents such as organizational culture and climate (e.g., Danneels, 2008; Teece et al., 1997), formal and informal structures (e.g., Jansen, Van Den Bosch, & Volberda, 2005), and process management (e.g., Benner & Tushman, 2003) affect dynamic capabilities.

However, Felin, Foss, and colleagues considered such pure organization-level relationships “explanatory shorthand” for more complicated sub-processes that occur at the individual level (Abell, Felin, & Foss, 2008; Felin & Foss, 2005, 2006, 2009; Felin & Hesterly, 2007). As these authors critically remarked, work that explains organization-level phenomena caused by origins that are also placed at the organizational level implicitly assumes that lower levels, namely, individuals or groups of individuals, are homogeneous and, thus, less important for theorizing about capabilities (see also Dansereau, Yammarino, & Kohles, 1999; Klein, Dansereau, & Hall, 1994). For example, Felin and Foss (2009) referred to the highly cited work of Henderson and Cockburn (1994), assuming, for instance, that employee turnover does not affect firm capabilities and viewing individuals as randomly assigned to organizations and perfectly malleable.

These assumptions can be strongly questioned on the basis of the early work by Lotka (1926, as cited in Felin & Hesterly, 2007), who revealed that individual-level performance may not be equally distributed among a population of individuals; he showed that only 5 out of 100 scientists produce more than 50 percent of the research output. Similarly, in a study of pharmaceutical firms, Rothaermel and Hess (2007) provided empirical evidence that intellectual human capital was heterogeneously spread across these companies and explained a significant amount of the differences in firm-level innovative output.

Taken together, empirical observations and the critiques regarding pure macro-level explanations of the causes of capabilities point to the need for investigating the micro-foundations of dynamic capabilities (Abell et al., 2008; Felin & Foss, 2005; Foss, 2009; Gavetti, 2005). That is, to better understand how firm-level capabilities are rooted in levels of analysis lower than the firm level – predominantly in the characteristics, conditions, behaviors, and interactions of individuals (Barney & Felin, 2013; Felin et al., 2012; Felin et al., 2015).

ORQ 3: How are dynamic capabilities formed and how can their effectiveness be fostered (management)?

Another critical issue within the dynamic capabilities literature concerns how the formation and effectiveness of these capabilities can be actively managed by firms (cf. Eggers & Kaplan, 2013). The formation of dynamic capabilities is not only a matter of searching for the capabilities' micro-level origins – as stated in the second overall question – but also of identifying what organizational conditions a firm can provide and what mechanisms it can use to influence micro-level factors to form dynamic capabilities (Rothaermel & Hess, 2007). Also, the question arises of how specific organizational conditions and mechanisms can be set in place to strengthen the performance of dynamic capabilities (Helfat & Peteraf, 2015).

With regard to the formation of dynamic capabilities, one reason why this issue has not received sufficient attention so far might have to do with the relative neglect of multilevel aspects of capabilities formation (Rothaermel & Hess, 2007; Salvato & Rerup, 2011). Often, phenomena in management theory are examined only on the focal level of analysis to simplify the analysis to some extent (Felin & Hesterly, 2007; Nelson & Winter, 1982). Research on the formation of capabilities is not an exception, although capabilities formation may involve socially complex actions and interactions (Collis, 1994), thus being inherently multilevel – as is the case for most management phenomena (Hitt et al., 2007). By concentrating on the organizational level when investigating firm-level heterogeneity in dynamic capabilities, such single-level capabilities research can be criticized for implicitly assuming that this level is largely independent from interplays with other higher (e.g., inter-organizational) or lower (e.g., team or individual) levels of analysis (cf. Dansereau et al., 1999; Felin & Hesterly, 2007; Rothaermel & Hess, 2007).

Thus, the related criticism that the extant work on dynamic capabilities predominantly lacks micro-level origins might only represent one missing part of the greater picture of how to form dynamic capabilities. When searching for micro-foundations, researchers may also consider the interplay of individual-level antecedents with factors at other levels by studying, for example, how the macro-level context to which individuals are exposed plays a role (Barney & Felin, 2013). Similarly, Abell et al. (2008) called for deeper exploration of how and what micro-level factors mediate the relationship between antecedents and capabilities at the macro level (see also Coleman, 1990). More advanced work on the formation of capabilities may also account for interactions among the individual, organizational, and network level (e.g., Rothaermel & Hess, 2007).

Regarding the enhancement of the effectiveness of dynamic capabilities, one encounters one of the most prominent points of criticism concerning the dynamic capabilities perspective, that is, the often implicit tautology of describing dynamic capabilities by including competitive advantage as part of the definition (Arend & Bromiley, 2009; Williamson, 1999; Zahra et al., 2006): If a firm possesses dynamic capabilities, it has to perform well, and if it performs well, it must have dynamic capabilities (Cepeda & Vera, 2007). This conceptualization makes it hard to differentiate the existence of dynamic capabilities from their outcomes (Schilke, 2014; Zahra et al., 2006). To counter this tautology, Helfat et al. (2007) argued that dynamic capabilities may first and foremost yield an alteration of the resource base, but not necessarily a successful one in terms of superior performance. Thus, when exploring the effectiveness of a dynamic capability, these authors proposed to disentangle the capability from firm performance and then clearly outline the relationship between the variables (see also Helfat & Martin, 2015).

Specifically, without such clear separation, an examination of how the performance effects of dynamic capabilities might be influenced by contextual factors is very difficult or nearly impossible. In contrast, a strict disentanglement of dynamic capabilities and performance outcomes may allow for unveiling whether a certain capability always leads to firm performance or whether specific conditions enable, strengthen, or impede their impact on performance (Barreto, 2010). While prior research has highlighted the contingent role of external environmental conditions (Schilke, 2014; Winter, 2003), less is known about the role of internal organizational conditions affecting the link between dynamic capabilities and firm performance (Helfat & Martin, 2015). For instance, some firms may possess better capabilities than other firms to modify their resources, but they may not profit from this superiority because they lack the right organizational structures and incentives to materialize their capabilities into a competitive advantage (Helfat & Peteraf, 2015).

Taken together, research is lacking on the organizational conditions that firms can provide to actively manage the formation and effectiveness of dynamic capabilities and how these organizational factors actually unfold their effect, that is, in conjunction with factors at other levels of analysis.

1.3 OVERVIEW OF THE DISSERTATION

Dissertation Structure

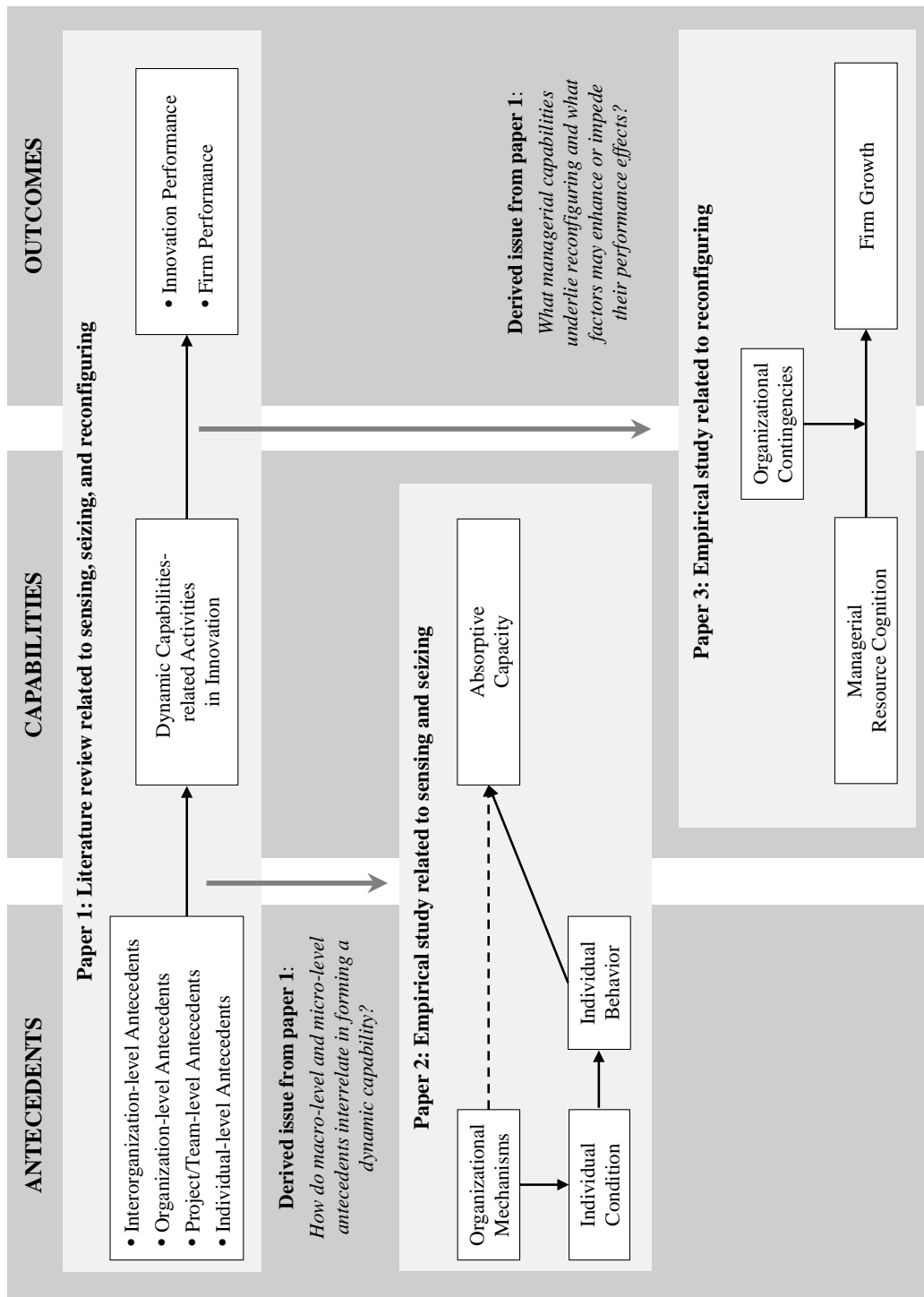
The dissertation aims to address the aforementioned overall research questions through three distinct and self-contained research papers. Naturally, as these questions are broadly defined, it is impossible to fully answer them. However, the three papers seek to shed new light on issues subsumed under the three questions to contribute to a better understanding of the nature, origins, and management of dynamic capabilities. Each paper deals with distinct examples of dynamic capabilities that can be assigned to – at least to some degree – one or more of the three clusters proposed by Teece (2007).

The first paper (Chapter 2) is a literature review and discussion of the capabilities-related innovation literature and investigates the multilevel antecedents and consequences of sensing-, seizing-, and reconfiguring-related activities. The second paper (Chapter 3) is an empirical study on the origins of firm-level absorptive capacity that explores macro-micro and micro-macro relationships and corresponds to the clusters of sensing and seizing capabilities. The third paper (Chapter 4) is an empirical study which conceptualizes resource cognition as a managerial capability that may underlie reconfiguring; it empirically examines the performance implications of this capability and organizational contingencies. Figure 1.1 embeds the three papers in an integrated conceptual model consisting of capabilities, their antecedents, and their outcomes and sketches how the two empirical papers build on the review paper.

Chapter 2 is titled *Dynamic Capabilities in Innovation: A Multilevel Review of Existing Research and Suggestions for the Future*. In this first research paper, I systematically review 142 empirical studies on product development and innovation that fit the three clusters of sensing, seizing, and/or reconfiguring analogously but do not necessarily use the term dynamic capabilities. In doing so, I address Helfat and Peteraf's (2009) call for analyzing prior empirical research that may be highly relevant to dynamic capabilities but not be labelled as such in order to advance our understanding of dynamic capabilities and build a basis for future empirical work. Specifically, I develop an integrative framework which highlights antecedents of dynamic capabilities-related activities in innovation at the individual, project/team, organizational, and interorganizational levels of analysis. Furthermore, the paper reveals how the different types of innovation activities related to the three clusters are interdependent with one another and that these activities are associated with innovation performance and firm performance. Based on the

findings of the review and on uncovered shortcomings in the extant literature, I develop several research suggestions for future research regarding the nature, antecedents, and consequences of dynamic capabilities in innovation.

Figure 1.1: Dissertation Outline by an Integrated Conceptual Model



Regarding the nature and locus of dynamic capabilities (ORQ 1), this review paper illustrates how capabilities may look in terms of more concrete innovation activities – mainly at the organizational level. Concerning the micro-foundations of dynamic capabilities (ORQ 2), the paper provides preliminary insights from innovation research into micro-level (i.e. individual and team level) factors that may influence dynamic capabilities. With regard to the management of dynamic capabilities (ORQ 3), the paper suggests a multilevel moderated mediation model of capability formation. For the further proceeding of the dissertation, two major issues which seem to be underexplored can be identified from the results of the literature review: First, how do macro-level antecedents and micro-level origins interrelate in forming a dynamic capability? Second, what managerial capabilities underlie reconfiguring and what factors can enhance or impede their performance effects? While the former issue will be addressed in the second research paper by using an established conceptualization of a widely accepted capability, that is, firm-level absorptive capacity, the latter issue will be addressed in the third research paper by developing further a recently introduced concept which may underlie resource reconfiguration, that is, managerial resource cognition.

Chapter 3 is titled *Origins of Firm-Level Absorptive Capacity: Exploring Macro-Micro and Micro-Macro Relationships*. Despite wide acceptance of the concept of absorptive capacity, our understanding of the origins of a firm's ability to absorb and leverage new knowledge is limited. Therefore, in this second research paper, I explore the multilevel antecedents of absorptive capacity by drawing on Coleman's (1990) bathtub model of macro-micro-macro-level interactions in social science. Five hypotheses which reflect the different paths of the bathtub model and a mediation effect are developed and then tested based on survey data gathered in 106 firms at two different levels of analysis – the firm level and the level of knowledge workers. The findings show that formal and informal integration mechanisms are positively related to absorptive capacity at the organizational level and that this relationship is mediated through a micro-level process consisting of knowledge workers' cognitive process of perspective-taking and their creative behavior.

With regard to the nature and locus of dynamic capabilities (ORQ 1), this empirical paper applies an established conceptualization of absorptive capacity in terms of a latent firm-level ability containing four dimensions. To reveal where this latent ability might originate (ORQ 2), the study reveals cognitive and behavioral characteristics of knowledge workers as important micro-foundations. With respect to the management of dynamic capabilities (ORQ 3), this study

discusses how firms can build a capability by influencing their employees through the provision of certain organizational conditions.

Chapter 4 is titled *Resource Cognition as a Managerial Capability: Investigating Performance Implications and Organizational Contingencies*. In this third research paper, I deal with managerial resource cognition, a concept Danneels (2011) recently introduced, which refers to the extent to which managers know and understand corporate resources. Although the concept seems to be helpful in understanding the managerial underpinnings of a firm's strategic resource adaptation, a more detailed conceptualization is lacking. Thus, in this paper, I further develop the concept in terms of top managers' cognitions about the firm's technology- and market-related resources. To explore the performance implications of this managerial capability and the organizational conditions under which it is most effective, I build three hypotheses and test them based on multi-source data for 127 firms. The findings show that higher managerial resource cognition (as a combination of technology- and market-related resource cognition) is associated with higher firm growth and that a decentralized organizational structure strengthens this association. Interestingly and contrary to what was hypothesized, the results also indicate that the interaction of resource cognition with decentralization on firm growth is highest when the top management team (TMT) is small rather than large.

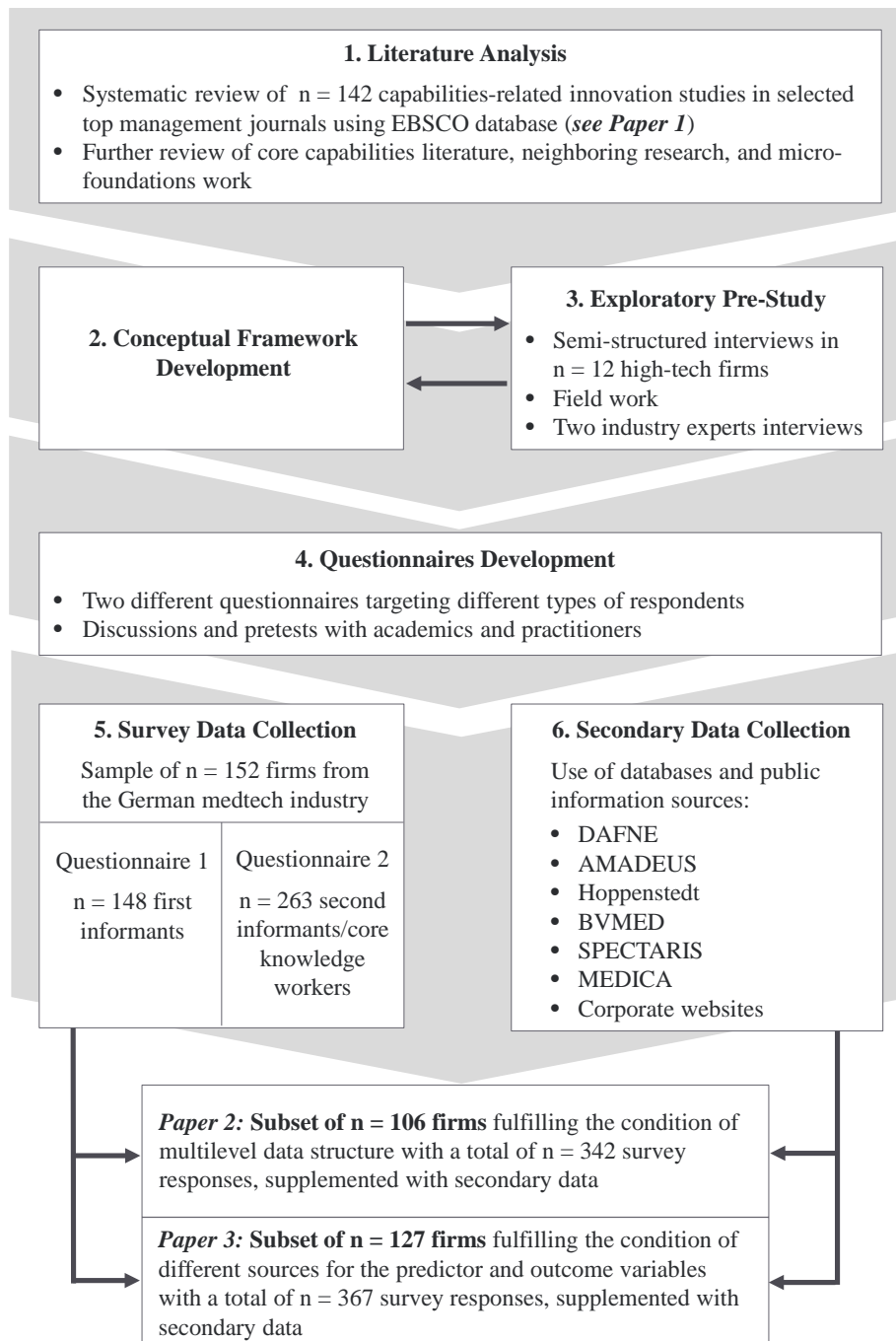
Regarding the nature and locus of dynamic capabilities (ORQ 1), this paper deepens the conceptualization of resource cognition as a so-called dynamic managerial capability by characterizing it as a cognitive activity of top managers underlying the reconfiguration of resources. Concerning the micro-foundations of dynamic capabilities (ORQ 2), this paper directly places the capability construct at the micro level and treats resource cognition as micro-foundational for firm-level performance. Concerning the management of a capability's effectiveness (ORQ 3), this study reveals important structural conditions through which firms can determine the internal information flow and the organizational context in which top managers make strategic decisions.

Research Process

The research process of this dissertation (including the different data sources used) is summarized in Figure 1.2 and started with a comprehensive *literature analysis*. In the first research paper, a qualitative literature review of extant capabilities-related studies in innovation research was applied. It employs a computerized search of relevant articles in the EBSCO Business Source

Complete database based on keywords which describe activities related to sensing, seizing, and reconfiguring in innovation. The search was conducted in selected top journals in the field of general management as well as specialty journals focusing on product development and innovation. A thorough selection process based on predefined criteria yielded 142 articles, which have been analyzed and systematically reviewed.

Figure 1.2: Research Process and Data Sources



In addition to the literature review in the first paper, I reviewed core capabilities-based literature and neighboring research on topics such as ambidexterity, organizational learning, and knowledge processes as well as the growing micro-foundations literature and relevant research into organizational behavior, top management teams, upper echelons, managerial cognition, human resource management, and organizational design. The literature analysis led to the *development of a conceptual framework* (similar to Figure 1.1). This framework embraced different linkages in a system of antecedents, capabilities, and outcomes. Thereby, it structured insights from extant work and spotted current research gaps. Based on this framework, I developed a research plan for the second research paper and the third research paper, which both represent quantitative-empirical studies. Although I will provide a more detailed description of the methodologies and data used in the methods sections of each paper, here I will give background information regarding the general empirical approach and data sources.

Informed by the conceptual framework, I developed a semi-structured interview guide for use in an *exploratory pre-study* to explore the practical relevance of theoretically developed propositions in the corporate reality and to identify an appropriate research setting for a large-scale quantitative-empirical study. Specifically, I conducted interviews with CEOs, heads of R&D, innovation managers, and other senior managers in 12 different companies. The firms ranged from small to large and were active in different high-tech sectors in Germany, including life sciences, medical technology, information technology, automation, and robotics. The interviews improved my understanding of which human resources and organizational characteristics may determine capabilities related to sensing, seizing, and reconfiguring (i.e., those individuals who actually carry out activities related to these capabilities). I also developed a better and more realistic comprehension of the (potential) interplay between organizational structures and mechanisms and employees' characteristics, such as their motivations, cognitions, abilities, actions, and interactions, in influencing capabilities and their effectiveness. The insights gained through these interviews were supplemented by additional field work, which included screenings of company-specific documents, publications provided by industry associations, on-site company visits, and a visit to a trade fair. As a result, the interviews led to refinements of the conceptual framework. Moreover, the interviews supported the operationalization of the concept of managerial resource cognition examined in the third paper and the development of appropriate scales.

I designed *two different questionnaires* on the basis of the conceptual framework and insights from the exploratory interviews. Questionnaire 1 mainly included scales for organizational structures, managerial capability, environmental characteristics, firm-level capabilities, and outcomes. Questionnaire 2 mainly included scales for employee cognition, expertise, and actions. The questionnaires also partly overlapped for some scales, such as constructs for firm-level outcomes and few employee attributes. With questionnaire 1, I targeted one top or senior manager per firm as a first informant because he or she had deep insights into not only firm-level characteristics, but also the cognitive abilities of the top management team, which represents the primary micro-level focus in the third research paper. With questionnaire 2, I targeted up to three core knowledge workers per firm as second informants because these individuals work closely with other knowledge workers throughout the innovation process and, thus, possess thorough information not only about their own characteristics but also about those of other knowledge workers – the group of key employees that is the object of study at the micro level in the second research paper. The questionnaires were originally formulated in English, then translated into German for the actual implementation of the survey, and eventually translated back into English, as reported in the chapters that follow. The questionnaire items were discussed with other management scholars and pre-tested with several managers.

The interviews and additional field work also revealed that the German medical technology industry offers an appropriate context in which to conduct a survey-based study to investigate the research issues addressed in the second and third paper. The medical technology sector is characterized by short product life cycles, a high rate of innovation, and a heterogeneous market structure consisting of a large number of different and frequently changing technologies (Eucomed, 2014). Thus, this industry setting clearly reflects an environment in which dynamic capabilities are likely to occur and be dynamic enough for firms to profit from them (Arend & Bromiley, 2009; Helfat & Martin, 2015). The suitability of this industry as research setting was further confirmed in phone interviews with two industry experts from the two main industry associations for medical technology in Germany (BVMed and SPECTARIS). The *survey data collection* was conducted in 2011/2012 and was based on a sampling frame of 407 relevant firms. The sampling frame was primarily derived from Creditreform, a comprehensive database listing companies located in Germany that allows for filtering out firms from certain industries – in this case, firms assigned the classification codes for medical technology WZ 266 and/or WZ 325. The

identification of the sampling frame will be described in more detail in the methods sections of each empirical paper (see Chapter 3 and Chapter 4).

From the 407 firms identified for the sampling frame, 152 participated in the survey with different numbers of returned questionnaires. Specifically, 148 responses were obtained for questionnaire 1 and 267 responses were obtained for questionnaire 2. However, three firms provided more than the requested maximum number of three second informants. Due to the lack of qualification of these additional informants and to be consistent among participating firms, their responses, four in total, were not considered for the analyses performed in this dissertation. This reduced the number of responses obtained for questionnaire 2 to 263. In addition to the primary survey data, a *secondary data collection* was conducted for TMT characteristics, firm characteristics, and industry segments for all 152 firms that participated in the survey. These secondary data were gained through the DAFNE and AMADEUS databases provided by the Bureau van Dijk and through the Hoppenstedt database.

To classify the firms into different, more specific medical technology segments, I screened their business descriptions available in the Bureau van Dijk and the Hoppenstedt databases. According to similar classifications for medical technology goods applied by the Federal Statistical Office of Germany (Güterverzeichnis des Statistischen Bundesamtes) and MEDICA, an international forum and trade fair for medicine, I assigned every firm to the medical technology segment in which it was predominantly active. The segments used for this dissertation included (1) surgical, diagnostic, and therapeutic devices and systems, (2) medical aids and implants, (3) lab technology and diagnostics, (4) dental products and instruments, and (5) medical furniture. In cases of doubt or when the information on the business objectives was missing in the databases, I further checked company profiles on the websites of the two German medical technology industry associations BVMed and SPECTARIS, the MEDICA forum's website, and the respective company's own corporate website. Also, if other information on firm characteristics (e.g., firm age) was not provided through the databases, I used the information found on corporate websites.

Table 1.2: Sample Descriptive Information

Firm characteristics	in %	Informant characteristics	in %
Primary medtech segment (n = 152)		First informants' function (n = 148)	
Surgical, diagnostic, and therapeutic devices and systems	43.4	Member of executive board	25.7
Medical aids and implants	26.3	Head of research & development	50.7
Lab technology and diagnostics	17.1	Head of marketing & sales	9.5
Dental products and instruments	9.9	Other senior manager or senior key employee (e.g., head of procurement, senior strategist)	14.2
Medical furniture	3.3		
Firm size (n = 152)		First informants' firm tenure (n = 148)	
< 50 employees	10.5	< 1 year	0.0
50 – 249 employees	51.3	1 – 5 years	25.7
250 – 499 employees	17.1	6 – 10 years	16.9
500 – 999 employees	8.6	11 – 15 years	25.7
1.000 – 4.999 employees	7.2	> 15 years	27.7
> 5.000 employees	5.3	Not specified	4.1
Firm age (n = 152)		Second informants' / core knowledge workers' function (n = 263)	
< 10 years	2.0	Research & development	70.0
10 – 24 years	34.9	Marketing	16.0
25 – 49 years	19.7	Product management	4.2
50 – 74 years	13.2	Other function (e.g., production, quality management)	9.9
75 – 99 years	14.5		
> 100 years	15.8		
		Second informants' / core knowledge workers' firm tenure (n = 263)	
		< 1 year	2.3
		1 – 5 years	32.7
		6 – 10 years	27.0
		11 – 15 years	18.3
		> 15 years	16.3
		Not specified	3.4

Note: Information about firm characteristics is taken from secondary databases and refers to n = 152 firms. Information about informant characteristics is gathered through survey questionnaires and telephone inquiries and is based on a total of n = 411 respondents.

Table 1.2 provides an overview of the characteristics of the sample firms and the informants who participated in the survey. Firms predominantly operating in the area of surgical, diagnostic, and therapeutic devices and systems represented the largest group among the different medtech segments. Only 10.5% was small companies with less than 50 employees, whereas most

of the sample firms can be considered medium-sized (i.e., 51.3% of the firms had up to 250 employees) or large (i.e., 38.2% had more than 250 employees). In terms of firm age (measured as years since founding), almost all firms were 10 years old or older. Overall, the median firm age was 37.5 years (mean = 55.7 years) and the median firm size was 189 employees (mean = 1,528 employees). Thus, most of the firms can be considered large and old enough to have established well-developed organizational structures, underscoring the suitability of the sample for studying the impact of such structures in the two empirical papers.

With regard to informant characteristics, the respondents exhibited a high degree of knowledgeable in terms of both their function within the firm and their firm tenure. In most cases, the first informants pertained to the firm's top and senior management as members of the executive board or in positions as functional heads. All of these informants had been with their firm for at least one year; most (i.e., 70.3%) had a firm tenure of six years or more. The second informants represented so-called core knowledge workers (Collins & Smith, 2006), employees who are crucial for knowledge generation and innovation, with an R&D function as the most frequently reported functional affiliation (70%), ahead of marketing, product management, and other knowledge-critical functions; 61.6% of core knowledge workers had been with their firm for at least six years. Overall, first informants had, on average, 13 years of firm experience (median = 12 years) and second informants/core knowledge workers had, on average, 9.5 years of firm experience (median = 8 years), implying that both types of respondents in the sample were highly knowledgeable.

Different data subsets from the base sample of 152 firms were derived for the second research paper and the third research paper according to the specific requirements for addressing the research questions of each paper. To account for the multilevel approach pursued in the second paper, I aimed to have per firm one first informant rating organization-level constructs (i.e., a top or senior manager) and two to three core knowledge workers for individual-level constructs to allow for some variability within the firm. This data structure condition was fulfilled by a subset of 106 firms of the base survey sample, including 106 first informants and 236 core knowledge workers. To handle the multilevel data and to account for both top-down (i.e., organization-individual) and bottom-up (i.e., individual-organization) relationships, I applied multilevel structural equation modeling (Preacher, Zyphur, & Zhang, 2010).

In the third paper, to limit issues associated with common method variance (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), I aimed to have per firm one first informant rating the managerial and organizational predictor variables and a minimum of one and up to three second informants rating the outcome variable. Moreover, to further diversify in terms of data sources, I included secondary data for TMT size as another main predictor variable. After eliminating cases with missing values, the final dataset for the third paper contained 127 firms of the base survey sample, with 127 first informants and 240 second informants (i.e., core knowledge workers). I performed hierarchical ordinary least squares (OLS) regression analyses by including interaction terms and conducting simple slope tests (Aiken & West, 1991) to account for hypothesized contingencies. Both papers used secondary data for general firm and industry characteristics.

As the two empirical papers draw on the same base sample data, it is important to justify the partial use of the same data by acknowledging the uniqueness of each paper (Kirkman & Chen, 2011). Apart from overlaps in terms of control variables, the second paper and the third paper use different main predictor and dependent variables and differ from one another in several ways. While the second paper focuses on absorptive capacity as an organizational capability, the third paper deals with top management's resource cognition understood as a managerial capability. The second paper explores the antecedents of a capability, whereas the third paper examines the performance consequences of a capability. Regarding the different organizational variables under study, integration mechanisms are treated as initial antecedents in a multilevel mediation chain explaining absorptive capacity in the second paper, whereas decentralization and TMT size are applied as moderating variables of the resource cognition-performance link in the third paper. In sum, although the two papers contribute to some of the same overall research questions of this dissertation, they focus on different types of capabilities and address and answer two clearly distinct and specific research questions.

1.4 FINAL REMARKS

This dissertation aims to contribute to a better understanding of the multilevel aspects of dynamic capabilities with a main focus on their micro-foundations. It explores the role of key organization members in defining and forming specific dynamic capabilities and investigates how the organizational context affects the emergence and effectiveness of these capabilities. This introduction established a common ground for the now following chapters which contain three independent research papers. These papers seek, each in their own right and with different

emphases, to advance our understanding of the nature, origins, and management of dynamic capabilities. In the final, concluding chapter (Chapter 5), the overall implications of the dissertation will be discussed.

Chapter 2

Dynamic Capabilities in Innovation: A Multilevel Review of Existing Research and Suggestions for the Future²

Abstract

Although dynamic capabilities occupy a central role in strategic management research, empirical studies that specifically focus on dynamic capabilities are relatively limited. Therefore, this paper responds to recent calls for further research; it analyzes 142 empirical studies in the field of innovation that fit with Teece's (2007) decomposition of dynamic capabilities into sensing, seizing, and reconfiguring but not necessarily using the term dynamic capabilities. Based on these studies, the paper generates new insights and develops an integrative framework that reveals the multilevel antecedents of dynamic capabilities-related activities in innovation, including their microfoundations. Furthermore, the study highlights how different types of dynamic capabilities-related activities are interdependent with one another and that these activities can lead to superior innovation and firm performance. Accordingly, the paper provides evidence supporting the existence and relevance of dynamic capabilities, and it increases our understanding of dynamic capabilities as a multilevel concept by clarifying prior conceptual work. Finally, based on identifying shortcomings in the empirical capabilities-related innovation literature, specific suggestions for future research on dynamic capabilities in innovation are developed.

Keywords: dynamic capabilities, innovation, microfoundations, multilevel, review.

² An earlier version of this paper was presented at the Academy of Management Annual Meeting 2012 in Boston. I thank Nicolai Foss, Mia Reinholdt Fosgaard, and Christian Geisler Asmussen for helpful suggestions and comments on a prior version. I also acknowledge the former team of the Chair of Organization at the University of Mannheim for conceptual discussions in the early stage of this paper.

2.1 INTRODUCTION

Strategic management research has long been preoccupied with the question why some firms prosper in the face of environmental changes while others fail. One of the most prominent approaches that addresses this question is the dynamic capabilities view (Teece et al., 1997). To cope with dynamic environments and to sustain superior performance over time, this view suggests that firms must continuously adapt and renew their resources (Helfat et al., 2007). Teece (2007) proposed that dynamic capabilities can be disaggregated into sensing, seizing, and reconfiguring capacity. Sensing capacity corresponds to the discovery and generation of new opportunities. Seizing capacity refers to the exploitation of opportunities by means of new products or processes, and reconfiguring capacity is related to the continuous reconfiguration and recombination of a firm's resources and structures to sustain competitiveness.

Despite dynamic capabilities being a growing field of research in different sub-disciplines (Barreto, 2010), the extant research on dynamic capabilities is often conceptual (Di Stefano et al., 2014; Zollo & Winter, 2002). The quantity of empirical work that specifically addresses dynamic capabilities is still relatively limited, and this relative lack of empirical research narrows our understanding of the concept (Leiblein, 2011; Zahra et al., 2006). However, many important insights may be gained from empirical studies in related fields, such as new product development, which is often used as a specific example of dynamic capabilities (Eisenhardt & Martin, 2000; Teece et al., 1997). As Eisenhardt and Martin (2000) stated, product development constitutes a well-known dynamic capability, but it has not often been labeled as such and has been studied without referring to the dynamic capabilities literature.

Therefore, the aim of this paper is to review innovation research that fits with the dynamic capabilities view without necessarily using the term dynamic capabilities. In doing this, I answer Helfat and Peteraf's (2009: 98) call "to survey empirical work that is relevant to dynamic capabilities, perhaps by topic (e.g. innovation), in order to learn what it may tell us about dynamic capabilities and enhance the foundation for future empirical research." Following Teece's (2007) disaggregation of dynamic capabilities into sensing, seizing, and reconfiguring capacity as a theoretical basis for my review, this paper makes several contributions to the field.

First, I increase the understanding of dynamic capabilities by systematically studying the empirical literature on one particular example of dynamic capabilities, that is, product development (Eisenhardt & Martin, 2000; Helfat & Winter, 2011). I reinterpret prior innovation

studies to provide empirical evidence supporting the existence and relevance of dynamic capabilities and to offer new theoretical insights to clarify their conceptual foundations (Helfat & Peteraf, 2009). I propose an integrative framework that highlights dynamic capabilities-related innovation activities, their antecedents, and their consequences. The framework further identifies six categories for systematizing the publications and for structuring my findings.

Second, this paper contributes to the multilevel perspective of dynamic capabilities (Eisenhardt & Martin, 2000; Rothaermel & Hess, 2007; Salvato & Rerup, 2011) by revealing that the antecedents of dynamic capabilities-related activities originate at the individual, team, organizational, and interorganizational levels of analysis. In particular, I identify individual-level factors from innovation studies that underscore the critical role of the microfoundations of dynamic capabilities and extend recent research endeavors into this field (Felin et al., 2012; Foss, 2009, 2011). Third, I contribute to the product development literature by showing that a firm's innovation processes themselves need to be adapted over time in order to maintain superior performance.

Finally, based on identifying deficits in the extant capabilities-related innovation research, I develop several suggestions for future research to foster theory development and testing. Specifically, I discuss the nature and role of reconfiguring and provide a model that exemplifies how antecedents at multiple levels interrelate in forming a capability. Furthermore, I propose to unfold the consequences of dynamic capabilities by differentiating between direct and ultimate outcomes and by considering the context in which dynamic capabilities are deployed.

2.2 THEORETICAL BACKGROUND

Consistent with earlier research (Teece et al., 1997; Zahra et al., 2006), a dynamic capability is defined as “the capacity of an organization to purposefully create, extend, or modify its resource base” (Helfat et al., 2007: 4). A dynamic capability can be distinguished from an operational (or ordinary) capability. Operational capabilities enable organizations to perform the ongoing activities of making a living in the present and maintaining the status quo. In contrast, dynamic capabilities enable firms to alter the way they make their living in the future (Winter, 2003). A capability qualifies as dynamic if it enables a firm to extend or modify its resource base, regardless of whether it causes a radical change for the firm or supports its prevailing businesses (Helfat & Winter, 2011). Consequently, and in line with Helfat and Winter's (2011) clarification of the term dynamic capability, I regard all kinds of capabilities for conducting new product

development or adapting the processes of product development as dynamic capabilities because these capabilities alter a firm's resource base in a certain way – even if only through modifications or improvements of existing products.

Prior research has specified and conceptualized dynamic capabilities as a multidimensional construct with underlying processes that alter a firm's resource and knowledge base by “leveraging existing resources, creating new resources, accessing external resources, and releasing resources” (Danneels, 2011: 1) or “knowledge creation and absorption, knowledge integration, and knowledge reconfiguration” (Verona & Ravasi, 2003: 579). These processes contain patterned activities, choices, and routines that a firm can use in a repeatable manner, thus excluding ad-hoc problem solving (Winter, 2003). Dynamic capabilities have been conceptually proposed to be shaped by the firm's internal asset positions and path-dependent learning mechanisms as well as factors of the external environment. Thus, dynamic capabilities may lead to competitive advantage (Eisenhardt & Martin, 2000; Teece et al., 1997; Winter, 2003).

Based on the multidimensional view of dynamic capabilities, I follow Teece's (2007) influential disaggregation of dynamic capabilities into sensing, seizing, and reconfiguring capacity with respect to new product development and innovation activities. Teece's (2007) view on dynamic capabilities is used in this paper because it provides an encompassing understanding of dynamic capabilities by integrating previous definitions in the literature in a structured manner. This disaggregation has been applied previously in work on dynamic capabilities (Helfat & Peteraf, 2015; Hodgkinson & Healey, 2011; Martin, 2011), and it is consistent with similar capability-based work on innovation (Branzei & Vertinsky, 2006; Marsh & Stock, 2006).

Sensing capacity refers to the recognition and generation of new opportunities and involves activities related to environmental scanning, learning, interpretation, and research (Teece, 2007). It concerns the exploration of new technologies and new markets (McGrath, 2001), and it corresponds to external knowledge absorption and internal knowledge creation (Cohen & Levinthal, 1990; Verona & Ravasi, 2003). Seizing capacity refers to the exploitation of opportunities through new products or processes by means of development and commercialization activities (Teece, 2007). It includes integrating new knowledge into the firm's knowledge base and linking the new knowledge to existing knowledge (Kogut & Zander, 1992; Verona & Ravasi, 2003). Reconfiguring capacity refers to retaining competitiveness by continuous reconfiguration and recombination of a firm's resources and structures in response to changing environments (Teece, 2007). It may also address the development and alteration of

other dynamic capabilities (Helfat & Peteraf, 2003; Zollo & Winter, 2002). Regarding innovation, reconfiguring capacity consists of activities in shaping and renewing the content of new product development processes and their adaptation to market and technological changes (Danneels, 2008; Salvato, 2009).

2.3 METHODOLOGY

I limited my review to articles published in 15 leading journals. Seeking to provide a comprehensive and thorough overview, I followed the procedure suggested by Short (2009) and selected the top journals in the field of general management as well as specialty journals with a particular focus on product development and innovation. My search scope included the following journals: *Academy of Management Journal*, *Administrative Science Quarterly*, *Industrial & Corporate Change*, *Journal of Business Venturing*, *Journal of International Business Studies*, *Journal of Management*, *Journal of Management Studies*, *Journal of Product Innovation Management*, *Long Range Planning*, *Management Science*, *Organization Science*, *Organization Studies*, *Research Policy*, *Strategic Management Journal*, and *Strategic Organization*.

To find relevant articles, I generated two groups of keywords. The first group included “innovation” and “product development” since this review focuses on innovation activities. The second group included keywords that describe or approximate activities related to sensing, seizing, and reconfiguring capacity, according to the understanding of Teece (2007). Keywords that approximate sensing include “environmental scanning”, “screening”, “monitoring”, “opportunity identification”, “opportunity recognition”, “opportunity discovery”, “opportunity generation”, “opportunity creation”, “knowledge generation”, “knowledge creation”, “idea generation”, “idea creation”, “technology exploration”, “technology discovery”, “technology generation”, “technology creation”, “technology recognition”, “technology intelligence”, “competitive intelligence”, “market intelligence”, “market analysis”, “exploration”, “shaping”, and “sensing”. Keywords that approximate seizing include “market orientation”, “knowledge integration”, “knowledge application”, “knowledge implementation”, “technology integration”, “technology application”, “technology implementation”, “business model”, “commercialization”, “product introduction”, “product launch”, “market introduction”, “market launch”, “exploitation”, and “seizing”. Keywords that approximate reconfiguring include “reconfiguring”, “redirecting”, “realigning”, “recombining”, “renewing”, “redesigning”, “redeploying”, “reorganizing”, “revamping”, and “transforming”. In addition, the second group of keywords also

included the terms “dynamic capabilities” and “organizational capabilities” to capture articles in innovation research that specifically use a capabilities-based lens.

I then conducted a computerized search of the literature in the *EBSCO Business Source Complete* database for all papers in the selected journals that contain at least one of the generated keywords of each group in their abstracts and were published by December 2011. Different endings of the keywords were allowed using the asterisk (*) for the searching process. For instance, searching for “opportunit* identif*” allowed for any word combination such as “opportunity identification,” “to identify opportunities,” and “identifying an opportunity.” This process yielded 3,117 hits. From these hits, I excluded all book reviews and editorials since they do not provide any empirical insights. Furthermore, articles that were found several times through different keywords were included only once for further analysis. I then scanned the abstracts of the remaining disjointed articles to identify those that are relevant to dynamic capabilities-related innovation activities. Articles whose abstracts include the above generated keywords, but in a way that does not imply any connection to dynamic capabilities-related activities, were discarded. For instance, an article with an abstract that includes the sensing-related keywords “technology exploration” in a sentence like “this study *explores* data from *technology*-focused firms” was not considered because the way in which the keywords are used does not induce a focus on dynamic capabilities-related activities. This selection resulted in 248 articles.

I collected copies of these articles and analyzed them in more detail with reference to the following three selection criteria. First, I concentrated exclusively on (quantitative and qualitative) empirical work, thus excluding articles of a merely theoretical or conceptual nature. Second, I excluded work that did not show any relevance to dynamic capabilities-related innovation activities despite an abstract that might have induced such relevance. Third, I explicitly considered studies that deal with the individual level, project/team level, organizational level, and interorganizational level because antecedents of dynamic capabilities and activities related to dynamic capabilities can be found at these levels of analysis (Eisenhardt & Martin, 2000; Teece et al., 1997; Zollo & Winter, 2002). These steps resulted in the final sample of 142 articles for my review. The identified literature was found in 14 of the aforementioned journals (*Organization Studies* did not feature any publications). The distribution of the publications per journal is indicated in Table 2.1.

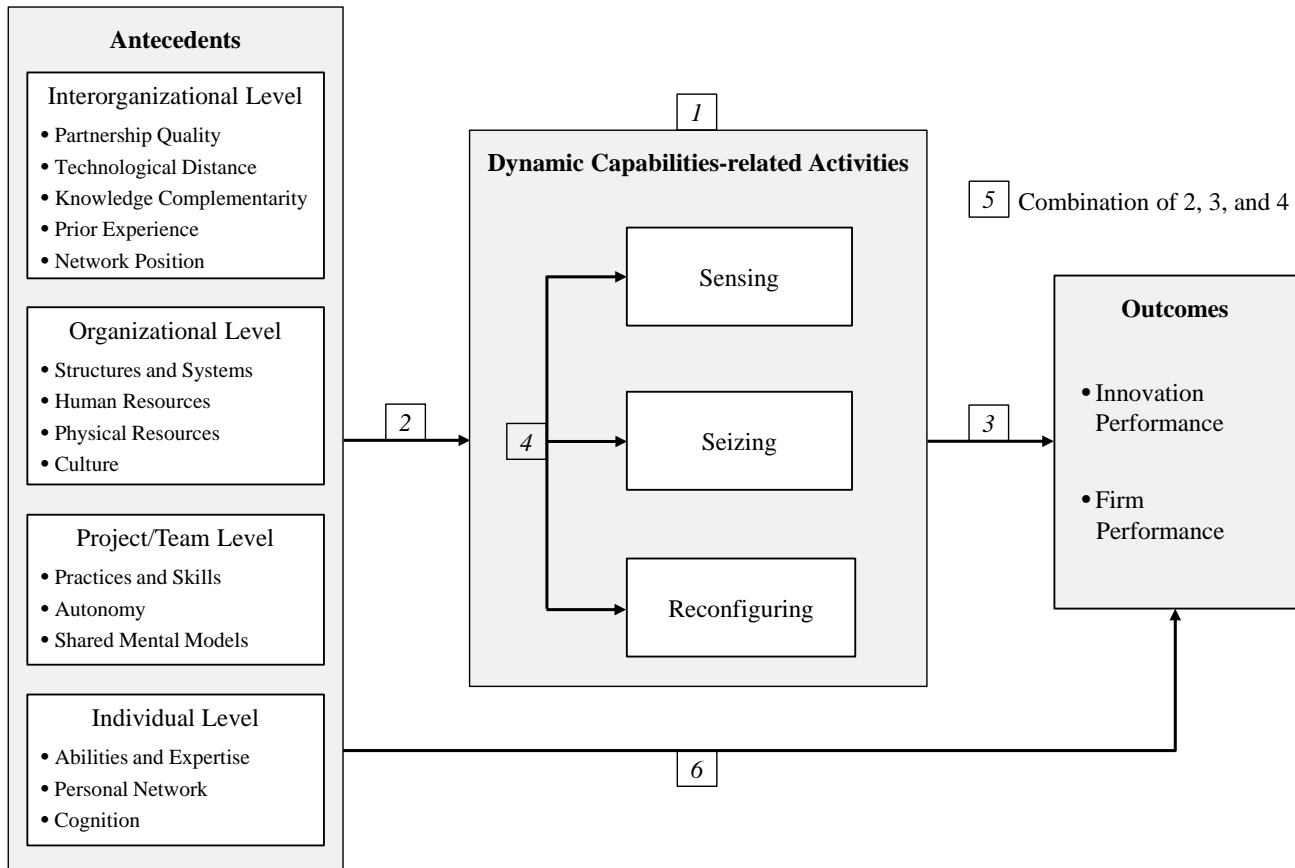
Table 2.1: Distribution of Articles per Journal

Journals	Number of Articles	
Journal of Product Innovation Management	71	(50.00%)
Long Range Planning	12	(8.45%)
Research Policy	10	(7.04%)
Strategic Management Journal	10	(7.04%)
Organization Science	9	(6.34%)
Academy of Management Journal	5	(3.54%)
Industrial & Corporate Change	6	(4.23%)
Management Science	6	(4.23%)
Journal of Management Studies	5	(3.52%)
Administrative Science Quarterly	3	(2.11%)
Journal of Business Venturing	2	(1.41%)
Journal of International Business Studies	1	(0.70%)
Journal of Management	1	(0.70%)
Strategic Organization	1	(0.70%)
Total	142	(100%)

2.4 RESULTS

Development of the Framework

To systematically evaluate the contribution of a given body of research, Ginsberg and Venkatraman (1985) suggested using an analytical review scheme (for a similar approach, see Hutzschenreuter & Kleindienst, 2006). Therefore, I developed an integrative framework that is built on a careful analysis of the identified articles. This framework is displayed in Figure 2.1 and reveals three components: (a) antecedents of dynamic capabilities-related activities, which are further grouped into individual-level, team/project-level, organization-level, and interorganization-level antecedents, (b) dynamic capabilities-related activities at all levels of analysis, which are divided into activities associated with sensing, seizing, and reconfiguring capacities, and (c) outcomes of the dynamic capabilities-related activities and the antecedents, which include two different outcomes: innovation performance and firm performance. Within this framework, the research falls into work that addresses different linkages among the three components, work that concerns interrelations among the three types of dynamic capabilities-related activities, and work that describes dynamic capabilities-related activities. Accordingly, I have identified six categories for systemizing the publications, as indicated in Figure 2.1.

Figure 2.1: An Integrative Framework of Dynamic Capabilities-related Activities

Note: The numbers indicate the six different categories for systemizing prior research.

Category 1 includes articles that reveal and describe the nature of dynamic capabilities-related activities without addressing linkages to the other components. This category consists of 38 reviewed articles. Category 2 includes articles that deal with antecedents' influence on dynamic capabilities-related activities and contains 25 out of the final sample of 142 reviewed articles. Category 3 includes articles that deal with dynamic capabilities-related activities' influence on outcomes and comprises 28 publications. Category 4 includes articles that deal with relationships among the three dynamic capabilities-related activities and consists of only 5 out of the 142 publications. Category 5 is a combination of categories 2, 3, and 4, and includes articles that deal either with both antecedents' influence on dynamic capabilities-related activities and dynamic capabilities-related activities' influence on outcomes or with interactions of different types of dynamic capabilities-related activities and their impact on outcomes. This category comprises 21 articles. Category 6 includes articles that deal with antecedents' direct influence on

outcomes, where dynamic capabilities can be assumed as an implicit explanation for this relationship without being explicitly measured. This category contains 25 publications. In the following, I synthesize the literature of the different categories by highlighting the essential findings.

Category 1: Describing Dynamic Capabilities-Related Activities

The largest body of the reviewed literature includes articles that reveal and describe the nature of activities related to sensing, seizing, and reconfiguring capacities without explicitly addressing linkages to antecedents or consequences. Work in this category can be grouped into studies that describe only one type of dynamic capabilities-related activity, studies that reveal a combination of two types of dynamic capabilities-related activity, and studies that highlight the multidimensional nature of dynamic capabilities by distinguishing between the different types of dynamic capabilities-related activity.

First, with regard to sensing, typical activities include environmental scanning and monitoring (Alam, 2003; Spanjol, Qualls, & Rosa, 2011), creativity techniques (Iwamura & Jog, 1991), and evaluation methods to determine which opportunity is worth pursuing (De Brentani, 1986; Majchrzak, Cooper, & Neece, 2004). Firms organize their sensing activities by assigning a specific function, for example, a particular person, group, or department (Iwamura & Jog, 1991; Kraushar, 1968), by establishing a climate that encourages employees to participate in new idea generation and acquisition (Felberg & DeMarco, 1992), and by employing a variety of idea sources including lead users (Lilien, Morrison, Searls, Sonnack, & von Hippel, 2002).

Concerning seizing, on the one hand, strategic activities such as product introduction timing and market positioning (Chiesa & Frattini, 2011) and the definition and continuous evolution of a business model to capture value from business opportunities (Amit & Zott, 2001; Demil & Lecocq, 2010; Sosna, Treviño-Rodríguez, & Velamuri, 2010) have been revealed. On the other hand, commercialization efforts to purposefully manage interactions with customers, such as product demonstration and ongoing customer service (Athaide, Meyers, & Wilemon, 1996), have been identified as more operational seizing activities. With reference to reconfiguring, reorganizing organizational routines and redefining unit and firm boundaries represent fundamental activities of organizational renewal (Karim & Mitchell, 2004; Ruiz-Navarro, 1998). These activities can include managerial interventions that convert successful everyday

experiments undertaken by individuals into new or adapted organizational capabilities (Salvato, 2009).

Second, a number of works treats sensing and seizing as tightly combined activities by specifying their content and organizational setting (Hart, Jan Hultink, Tzokas, & Commandeur, 2003; O'Connor & DeMartino, 2006; Veryzer, 1998; Wood & Brown, 1998). For instance, the combined sensing and seizing activities can be organized as a specific function or internal to individual projects (Söderquist, 2006). Furthermore, these activities may be embedded in an internal network interlinking different functions and units (Harryson, Dudkowski, & Stern, 2008; Peltokorpi, Nonaka, & Kodama, 2007; Zander, 2002) or in an external network integrating external knowledge (Kodama, 2009; Snow, Fjeldstad, Lettl, & Miles, 2011; Tripsas, 1997).

Third, a few studies support the multidimensional nature of dynamic capabilities. For instance, the disaggregation of dynamic capabilities into activities related and similar to sensing, seizing, and reconfiguring has been described in the context of open source software development (Dahlander & Magnusson, 2008). Moreover, sensing and seizing activities can be regarded as specialized capabilities or first-order competences that effectively perform specific tasks, whereas reconfiguring activities can be understood as general capabilities or second-order competences that reflect the ability to modify existing or build new specialized capabilities or first-order competences (Craig, 1996; Danneels, 2002). In Appendix 2.1, summaries of the publications in this category are provided, including information about the methods used, the level of analysis, the type of dynamic capabilities-related activities examined, and the key findings.

Category 2: Antecedents' Influence on Dynamic Capabilities-Related Activities

This category synthesizes the literature that deals with antecedents of activities related to sensing, seizing, and reconfiguring capacities. It is further structured into the individual level, team/project level, organizational level, and interorganizational level.

Individual level. Concerning the individual level, the size, diversity, and density of an individual's personal network can affect his or her activities related to sensing and seizing. More social ties within an individual's personal network increase the amount of high-quality ideas generated because the person has greater access to knowledge (Björk & Magnusson, 2009). In addition, a diverse personal network provides an individual with heterogeneous knowledge (Rodan & Galunic, 2004) and dense social ties within a diverse personal network facilitate the interpretation and integration of different and complex knowledge (Mors, 2010). However, in

homogeneous contexts, an individual is likely to have difficulty accessing diverse knowledge, and thus he or she benefits more from open networks characterized by low density (Mors, 2010).

Project/team level. Determinants of sensing and seizing activities at the level of projects and teams have been explored with regard to a project's or team's linking with the organizational structure and to factors affecting a project team's knowledge processing. Exploration activities of project teams are more effective when the project teams are somewhat detached from the organizational structure and operates with autonomy regarding their goals and supervision (McGrath, 2001). Knowledge creation and knowledge implementation in project teams are facilitated by the use of project management practices, such as information and communication technology tools (Vaccaro, Veloso, & Brusoni, 2009), as well as by the team members' shared mental models, including collective values and beliefs, because they lead a team to common decision-making, commitment, and actions (Berchicci & Tucci, 2010; Lindgren & O'Connor, 2011).

Organizational level. Concerning the organizational level, I draw on Verona and Ravasi's (2003) organizational building blocks of dynamic capabilities, which include structures and systems, human resources, physical resources, and culture. Regarding structures and systems, I identify three main elements that influence dynamic capabilities-related activities based on the literature review: formalization, decentralization, and coordination mechanisms.

Formalization has an impact on dynamic capabilities-related activities, although the direction of this effect differs across studies and depends on what exactly is being formalized. On the one hand, a high degree of formalization in terms of general reporting procedures and rules (Persaud, 2005) and rigid planning processes (Song, Im, Bij, & Song, 2011) impedes sensing and seizing. On the other hand, a clearly formalized new product development process can enhance sensing and seizing (Branzei & Vertinsky, 2006; Khurana & Rosenthal, 1998; Ordanini, Rubera, & Sala, 2008). Also, formalized methods, such as innovation benchmarking techniques and regular evaluations of proposals for new initiatives according to predefined criteria, may positively contribute to a firm's reconfiguring capacity because these methods help to redirect the new product development organization and the firm's knowledge assets (Pierz, 1995; Verona & Ravasi, 2003).

Decentralized organizational structures where individual units make decisions affecting their resources increase a firm's sensing and seizing capacities (Mudambi, Mudambi, & Navarra,

2007; Persaud, 2005; Verona & Ravasi, 2003). Coordination in the form of formal and informal collaboration between and within different business units and departments in general (Frost & Zhou, 2005; Mudambi et al., 2007; Schulze & Hoegl, 2008; Subramaniam, 2006) and between different functional areas such as research and development (R&D) and marketing in particular (Ordanini et al., 2008; Verona & Ravasi, 2003) allow for a continuous and intensive knowledge exchange between similar and different areas of expertise, and thus foster a firm's activities related to sensing and seizing.

With regard to the management of human resources, I find that investments in attracting, retaining, and training highly skilled and motivated personnel (Branzei & Vertinsky, 2006; Verona & Ravasi, 2003) as well as identifying and nurturing key personnel roles within the new product development process (Markham, Ward, Aiman-Smith, & Kingon, 2010) contribute to all three types of activities related to dynamic capabilities. Investments in physical resources, such as information technology systems, libraries, research facilities, and workplace layout, enhance dynamic capabilities-related activities as these resources foster knowledge absorption, creation, integration, and reconfiguration (Verona & Ravasi, 2003). Dynamic capabilities-related activities are also driven by an organizational culture that favors creativity, innovation, and organizational commitment and that reduces departmental thinking (Khurana & Rosenthal, 1998; Verona & Ravasi, 2003).

Interorganizational level. Sensing activities at the interorganizational level are influenced by the quality of the partnership and technological distance between collaborating firms. With respect to partnership quality, especially partner trust, partner familiarity and communications between the partners' technology experts represent strong predictors of effective knowledge acquisition in collaborations (Sherwood & Covin, 2008). Sensing through interfirm relations is further strengthened if the distance between the partners' technological knowledge bases is large, thus providing more opportunities to learn knowledge that is relatively new to the firm (Van de Vrande, Vanhaverbeke, & Duysters, 2011). The results of this category are shown in Appendix 2.2.

Category 3: Dynamic Capabilities-Related Activities' Influence on Outcomes

Five groups of studies dealing with outcomes of different and/or combined aspects and activities for sensing, seizing, and reconfiguring are identified in this category.

The first group includes studies examining environmental scanning as a specific sensing activity providing the firm with information from the environment in order to identify new opportunities. Depending on the environmental sectors on which environmental scanning focuses, different implications about its outcome effects can be drawn. Scanning the technological environment is positively related to innovation performance (Frishammar & Åke Hörte, 2005) and firm performance (Garg, Walters, & Priem, 2003). However, scanning the market and competitive environment is only positively related to innovation performance if it is built on a broad information basis and not restricted to current aspects of the market and competitive environment (Frishammar & Åke Hörte, 2005; Sidhu, Commandeur, & Volberda, 2007). Scanning the more general environment including sociocultural, economic, political, and legal aspects positively affects firm performance (Garg et al., 2003), but not innovation outcomes (Frishammar & Åke Hörte, 2005), as these aspects might be too broad to draw direct implications for new product development.

The second group of studies addresses outcomes of market orientation which can be regarded as a firm's combined capacity for sensing and seizing because market orientation refers to a firm's ability to collect market intelligence about competitors and customers, interpret this intelligence, disseminate it, and respond to it (Kohli & Jaworski, 1990). Empirical evidence is found for market orientation's positive impact on innovation performance (Atuahene-Gima, Slater, & Olson, 2005; Baker & Sinkula, 2007; Kahn, 2001) and, in turn, on firm performance (De Luca, Verona, & Vicari, 2010). The market orientation-innovation performance link can be reinforced by organizational factors that ensure a firm's commitment to market orientation and its effective execution (De Luca et al., 2010; Van Riel, Lemmink, & Ouwersloot, 2004) and by environmental turbulence (Calantone, Garcia, & Dröge, 2003).

The third group of studies dealing with consequences contains articles that refer to the notion of knowledge acquisition, generation, and integration as approximation of a firm's sensing and seizing capacity. Internal knowledge generation (Frenz & Ietto-Gillies, 2009) and external knowledge acquisition (Phene, Fladmoe-Lindquist, & Marsh, 2006) are positively related to innovation performance. Interactions between internal and external knowledge sources even

increase the innovation outcome potential because internal knowledge facilitates the recognition and transfer of external knowledge (Grimpe & Kaiser, 2010). Subsequent knowledge integration through intensive communication between different functional areas and linking newly acquired knowledge to the existing knowledge base also increases innovation outcomes (Iansiti & Clark, 1994; Kusunoki, Nonaka, & Nagata, 1998; Sheremata, 2002).

The fourth group of studies highlights activities related to sensing and seizing that are associated with the different stages of the new product development process and positively influence both innovation and firm performance. In the pre-development phase, such sensing activities include market research (Song & Thieme, 2009), initial screening of ideas (Barczak, 1995), and early product definition (Cooper & Kleinschmidt, 1993). During the development and commercialization phase, examples of performance-enhancing seizing activities are prototype testing (Barczak, 1995), tactics to lower diffusion barriers (Talke & Hultink, 2010), strong sales and distribution efforts (Calantone, Vickery, & Dröge, 1995; Di Benedetto, 1999), and promotion activities (Mishra, Kim, & Lee, 1996).

The fifth and smallest group of studies considers the consequences of a firm's reconfiguring capacity. Business unit reorganization that reflects the transformation of a firm's structures has a U-shaped relationship with innovation performance (Karim, 2009), implying that firms may not immediately profit from reorganization. However, when firms have experienced several reorganization events, learning from prior events can occur and may lead to superior innovation performance in the long run. In interfirm technology development projects, a continuous realignment of joint innovation processes and objectives through rotating leadership between the collaborating firms may increase innovation performance (Davis & Eisenhardt, 2011). Appendix 2.3 presents an overview of the studies in this category.

Category 4: Relationships among Multiple Dynamic Capabilities-Related Activities

Only a limited number of articles has explored how one type of activity related to sensing, seizing, and reconfiguring capacities affects another type. By reviewing these studies, I find three different relationships between the different types of dynamic capabilities-related activities.

First, sensing in the form of environmental scanning is positively related to seizing activities, such as the development and commercialization of new products (Arbussà & Coenders, 2007; Fontana, Geuna, & Matt, 2006), underscoring that sensing capacity may constitute an essential basis for subsequent seizing capacity. Second, exploration activities are identified as

being interrelated with exploitation activities through intermediary learning processes (Holmqvist, 2004) and specific organizational mechanisms (Kauppila, 2010), showing that sensing capacity and seizing capacity are complementary and that firms may balance the development of these two capacities. Third, sensing and seizing in the form of R&D activities might force organization members to rethink the configuration of the firm's processes and resources, revealing that sensing and seizing capacities may contribute to reconfiguring capacity (Nonaka & Yamanouchi, 1989). These results are displayed in Appendix 2.4.

Category 5: Combination of Categories 2, 3, and 4

This category contains studies that examine more than one of the linkages considered in the previous categories, and these studies can be grouped into two parts. The first part includes studies dealing with both antecedents and consequences of dynamic capabilities-related activities at various levels of analysis. The second part comprises works exploring interrelations of different types of dynamic capabilities-related activities and their impact on outcomes.

With regard to the first part of this category, activities related to sensing and seizing at the *individual level* and respective innovation outcomes are positively affected by an individual's breadth of expertise and interest and his or her belief in being able to influence the environment (Howell & Shea, 2001). Concerning *the project and team level*, project management practices (Lynn, Skov, & Abel, 1999), different team skills (Song, Souder, & Dyer, 1997; Talke, Salomo, & Kock, 2011), and shared mental models and processes among team members (Akgün, Keskin, & Byrne, 2010; Akgün, Lynn, & Byrne, 2006) are revealed as drivers of a team's sensing, seizing, and reconfiguring activities to achieve product development performance goals.

Several works affirm the influence of *organization-level* factors corresponding to organizational systems, structures, and culture on a firm's activities related to sensing, seizing, and reconfiguring and, in turn, on innovation outcomes (Kleinschmidt, De Brentani, & Salomo, 2007; Marsh & Stock, 2006; Paladino, 2007, 2008; Wei & Morgan, 2004). At the *interorganizational level*, empirical evidence is provided supporting the importance of partnership quality and a firm's network position for sensing and seizing activities and their positive effects on innovation outcomes (Yli-Renko, Autio, & Sapienza, 2001). Taken together, although some of these antecedents and outcome effects have already been identified by studies in the previous categories, studies presented in this part give a more comprehensive and thorough

understanding of dynamic capabilities by exploring what factors drive dynamic capabilities-related activities toward increased innovation performance.

With regard to the second part of this category, several studies highlight that sensing in the form of exploration activities and seizing in the form of exploitation activities have complementary effects on innovation and firm performance (Henard & McFadyen, 2005; Rothaermel & Deeds, 2004). These research results indicate that the exploration of new opportunities is economically useless until they are exploited and firms which conduct only exploitation at the expense of exploration activities tend to overlook new promising opportunities and, in turn, risk losing their competitive advantage in the future (Baker & Sinkula, 2005). Furthermore, some studies reveal that a firm's combined sensing and seizing capacity in the form of market orientation can lead to superior innovation outcomes if the market orientation induces other sensing and seizing activities during the new product development process, such as pre-development, development, and launch activities (Atuahene-Gima, 1995; Langerak, Hultink, & Robben, 2004; Morgan & Berthon, 2008). This finding implies that firms may have to undertake additional innovation activities to profit from their market orientation. Appendix 2.5 shows the results of this category.

Category 6: Antecedents' Direct Influence on Outcomes

This body of research deals with antecedents' direct influence on outcomes where dynamic capabilities can be assumed to explain this relationship without being explicitly measured. Consistent with Category 2, this category is structured into the different levels of analysis.

Individual level. The two studies in this category that deal with individual-level antecedents are concerned with outcome effects of individuals' cognition. The analysis of different cognitive styles for acquiring and using knowledge to problem-solve reveals that individuals with creative and conformist styles enhance radical innovation outcomes (Miron-Spektor, Erez, & Naveh, 2011). At the top management level, the chief executive officer's attention to emerging technologies influences entry timing into a new technology market and the degree and direction of strategic renewal (Eggers & Kaplan, 2009). Taken together, individual cognition can be assumed to affect a firm's capacities to sense and seize new technological opportunities and reconfigure its resource base to adapt to new market conditions.

Project/team level. Concerning the project and team level, several studies have underscored the importance of project management practices, such as formalized procedures,

progress reviews (Tatikonda & Montoya-Weiss, 2001), and the integration of different functions in the project work (Brettel, Heinemann, Engelen, & Neubauer, 2011; Ginn & Rubenstein, 1986; Souder, Sherman, & Davies-Cooper, 1998), for successful product development. Furthermore, a team's skills, such as team members' overall experience, and a team's unconscious mental processes, such as team intuition, may be appropriate when confronting complex innovation tasks (Dayan & Elbanna, 2011). In addition, teams that act with greater autonomy regarding their work activities and decisions have higher achievement of their new product development objectives (Tatikonda & Montoya-Weiss, 2001). As all these factors facilitate team learning and creativity, ensure efficient knowledge integration, and provide control over project tasks, I suppose these factors contribute to a project team's sensing and seizing activities.

Organizational level. In following Verona and Ravasi's (2003) systematization of the organization-level building blocks of dynamic capabilities, various studies have investigated the impact of organizational factors on outcomes. Regarding structures and systems, these can be further structured into the three elements already identified in Category 2.

A high degree of overall formalization facilitates a firm's implementation of knowledge and, thus, promotes exploitative innovation; however, it may impede exploratory innovation because it can constrain experimentation efforts (Jansen, Van Den Bosch, & Volberda, 2006; Leiponen, 2006). The same is found for specific, formalized management methods such as total quality management (TQM) and Six Sigma as they guide work processes but may impede improvisation (Benner, 2009; Benner & Tushman, 2002). Therefore, I assume formalization more generally when it refers to the overall organization but also specifically when it concerns certain methods to improve the efficiency of organizational operations supportive of a firm's seizing capacity, but hindering its sensing capacity.

A high degree of centralization narrows communication channels and decreases employees' self-determination and their efforts to seek innovative solutions, and thus it negatively influences exploratory innovation (Jansen et al., 2006). Hence, I suggest that centralized structures are obstructive for a firm's sensing capacity. A high level of informal coordination (e.g., open communication) within and between organizational units or functions increases opportunities to share, combine, develop, and implement knowledge from different areas of expertise and, thus, enables a firm to increase both its exploratory and its exploitative innovation output (Jansen et al., 2006; Subramaniam & Youndt, 2005). Therefore, I assume intense and diverse coordination mechanisms to foster a firm's sensing and seizing capacities.

With reference to human resources, employees' overall level of skills and knowledge per se may not foster innovation performance. However, in interaction with a high level of informal coordination, human resources positively affect innovation outcomes (Subramaniam & Youndt, 2005). I can conclude that employees' overall skills are supportive of a firm's sensing and seizing capacities if employees are networked and their knowledge is exchanged. Physical resources related to the management and storage of knowledge, such as databases, manuals, and patents, enhance the reinforcing of prevailing knowledge and increase incremental innovation outcomes (Subramaniam & Youndt, 2005). Therefore, I assume that these physical resources are supportive of a firm's seizing capacity. With regard to organizational culture, a clear and specific vision of a desired product market for a new technology positively affects innovation outcomes (Reid & De Brentani, 2010). Thus, market vision may underpin a firm's sensing and seizing capacities by giving employees a clear frame of reference that helps them recognize and realize innovation opportunities relevant to the firm.

Interorganizational level. In general, interorganizational investments to enhance a firm's R&D, such as alliances (Knudsen, 2007) and acquisitions (Makri, Hitt, & Lane, 2010), increase innovation outcomes and therefore can be assumed to contribute to a firm's sensing and seizing capacities. With regard to alliances, this is particularly the case when the focal firm pursues relationships characterized by a high level of density and involvement (Wadhwa & Kotha, 2006), has prior experience with external partners (Bierly, Damanpour, & Santoro, 2009), collaborates with partners that possess complementary knowledge (Fang, 2011), and holds a central position in its network of relationships (Gilsing, Nooteboom, Vanhaverbeke, Duysters, & van den Oord, 2008). Sensing might be reinforced by relations with technologically diverse and distant partners as knowledge from different and more distant areas is applied more to exploratory innovation (Bierly et al., 2009; Phelps, 2010). With regard to acquisitions, knowledge complementarity with the target firm can even drive the acquiring firm's strategic renewal (Makri et al., 2010) and, thus, may account for its reconfiguring capacity.

Multilevel. In one study, antecedents at the individual, organizational, and interorganizational level have direct and interaction effects on firm-level innovation output (Rothaermel & Hess, 2007). The study findings imply that individuals' abilities may be particularly important antecedents of firm-level dynamic capabilities-related activities and acquisitions of high-tech firms may contribute to a firm's reconfiguring capacity by adding new R&D competences to the firm. Furthermore, antecedents at different levels might serve as

complements to or substitutes for one another by influencing a firm's dynamic capabilities-related activities. The studies in this category are displayed in Appendix 2.6.

An Integrative Perspective

With regard to the six different categories, Category 1, which includes literature describing dynamic capabilities-related activities, represents the largest and most comprehensive category (27% of all studies) as studies in this category give specific examples of all three types of activities. Category 4, which includes studies that explore the influence of one or two types of dynamic capabilities-related activities on another, is by far the smallest category (4% of all studies), showing that research which examines interrelations of different types of dynamic capabilities is strongly under-explored.

With respect to the different types of dynamic capabilities-related activities (see Table 2.2), I find the empirical innovation literature to be dominated by studies focusing on sensing and/or seizing (86% of all studies). By comparison, studies dealing with reconfiguring alone or in combination with at least one of the other two types of dynamic capabilities-related activities are underrepresented (only 14% of all studies). Hence, many insights can be gained regarding firms' activities in identifying, shaping, and exploiting innovation opportunities and their respective antecedents and consequences, but the firms' activities related to reconfiguring their innovation processes and transforming their resources are relatively under-researched.

Table 2.2: Distribution of Articles in Terms of Types of Activities

Types of DC-related Activities	Number of Articles	
Sensing	29	(20.42%)
Seizing	14	(9.86%)
Reconfiguring	9	(6.34%)
Sensing and seizing	79	(55.63%)
Sensing and reconfiguring	3	(2.11%)
Seizing and reconfiguring	1	(0.70%)
Sensing, seizing, and reconfiguring	7	(4.93%)
Total	142	(100%)

As to the levels of analysis (see Table 2.3), 87% of all publications represents studies focusing on only one level of analysis, with most emphasizing the organizational level (63% of all studies). By focusing on one level, these studies implicitly assume that most of the

heterogeneity can be explained at the chosen level and that other levels are pretty much homogeneous and independent from the chosen level. Only 13% of all publications represents cross-level studies (i.e., studies dealing with more than one level). Most of these studies have examined the influence of antecedents located at levels other than the firm level on firm-level capabilities or outcomes, indicating that heterogeneity at levels other than the firm level may explain some of the firm-level heterogeneity. Thus, consistent with previous work (Felin & Foss, 2005; Felin & Hesterly, 2007; Rothaermel & Hess, 2007), assuming homogeneity in and independence from alternate levels may lead to erroneous empirical results.

Table 2.3: Distribution of Articles in Terms of Levels of Analysis

Level of Analysis	Number of Articles	
Individual level	4	(2.82%)
Project/team level	22	(15.49%)
Organizational level	90	(63.38%)
Interorganizational level	7	(4.93%)
Individual and project/team level	2	(1.41%)
Individual and organizational level	3	(2.11%)
Project/team level and organizational level	1	(0.70%)
Organizational and interorganizational level	12	(8.45%)
Individual, organizational, and interorganizational level	1	(0.70%)
<i>Total</i>	<i>142</i>	<i>(100%)</i>

When looking at how the reviewed articles explicitly or implicitly conceptualize the activities related to sensing, seizing, and reconfiguring capacities regarding the different levels of analysis, the following stands out (see Table 2.4). While the literature relatively frequently deals with sensing and seizing at the organizational level (65% of article counts), these two types of capacities have been conceptualized to a much lesser extent at the project/team level (15%) and the interorganizational level (8%). However, these capacities have seldom been conceptualized at the individual level in the reviewed literature (4%). When only considering the small group of 21 studies that address reconfiguring, most of these studies (17 out of 21) treat reconfiguring at the organizational level, whereas only a very few conceptualize reconfiguring at the interorganizational level (1 study out of 21), at the project/team level (2 studies out of 21), or at the individual level (2 studies out of 21). In short, the dynamic capabilities-related activities are predominantly defined as firm-level processes, routines or the like, but to a much lesser degree in terms of organization members, either as individual members or as groups of individuals, and in

terms of residing in interorganizational collaborations. This picture becomes even more obvious when considering reconfiguring activities only.

Table 2.4: Distribution of Articles in Terms of Conceptualizations at Different Levels

	Sensing	Seizing	Reconfiguring	Total
Individual level	7 (2.83%)	2 (0.81%)	2 (0.81%)	11 (4.45%)
Project/team level	19 (7.69%)	18 (7.29%)	2 (0.81%)	39 (15.79%)
Organizational level	86 (34.82%)	74 (29.96%)	16 (6.48%)	176 (71.26%)
Interorganizational level	11 (4.45%)	9 (3.64%)	1 (0.40%)	21 (8.50%)
Total	123 (49.80%)	103 (41.70%)	21 (8.50%)	247 (100%)

Note: The numbers indicate how many of the reviewed studies conceptualize the respective dynamic capabilities-related activities at the different levels of analysis. The total number of article counts in this table ($n = 247$) is higher than the total number of reviewed articles ($n = 142$) because articles dealing with more than one type of dynamic capabilities-related activities and/or more than one level have been counted several times and, thus, are contained in several cells.

Concerning the methodology (see Table 2.5), 70% of the studies uses quantitative research methods, such as surveys, secondary data, or experiments, whereas 30% of the studies uses qualitative methods (case study research). Not surprisingly, most studies in Category 1, which concentrate on describing dynamic capabilities-related activities, are case studies (76% of the studies in this category). Moreover, a closer look at the different types of dynamic capabilities-related activities unveils that 55% of the studies dealing with reconfiguring apply case study methods, in contrast to the literature treating sensing and seizing, where case study research accounts only for 25% of the studies. This finding is consistent with the observation that much of the extant empirical work in dynamic capabilities regarding the reconfiguration of resources is still exploratory in nature, employing case study methods (e.g., Danneels, 2011; Martin, 2011; Salvato, 2009).

Table 2.5: Distribution of Articles in Terms of Methods Used

Methods	Number of Articles	
Survey	70	(49.30%)
Secondary data	25	(17.61%)
Survey and secondary data	4	(2.82%)
Experiment	1	(0.70%)
Case study	42	(29.58%)
Total	142	(100%)

2.5 DISCUSSION

In the previous section, I reviewed the extant empirical work on innovation activities that is relevant to dynamic capabilities. For a systematic analysis of the literature, I developed an integrative framework including antecedents, dynamic capabilities-related activities, and outcomes. According to this, I proposed six categories for systemizing the publications and for structuring my findings. The implications of my review are twofold. Based on the findings, I first provide insights for dynamic capabilities research by comparing suggestions from prior prominent conceptual work on dynamic capabilities with my findings from empirical innovation research. Second, I provide insights for innovation research by revealing aspects from dynamic capabilities that are relevant to innovation. Certainly, these implications are not all-encompassing, but they highlight selected, in my view, important insights that aim to clarify the conceptual foundations of dynamic capabilities and open up new avenues for innovation research.

Insights for Dynamic Capabilities Research

Building on propositions of influential conceptual work on dynamic capabilities, I draw on my integrative framework (see Figure 2.1) and discuss essential insights from prior empirical innovation work that specifies and tests the multilevel antecedents and consequences of dynamic capabilities-related activities.

Concerning *individual-level antecedents*, Adner and Helfat (2003) suggested that dynamic capabilities are rooted in three individual-level factors:³ human capital which refers to individuals' abilities and expertise, social capital which refers to individuals' personal network

³ In Adner and Helfat's (2003) framework, these factors are referred to the managerial level. However, here their framework is applied to the individual level more generally because the basic meaning of these factors may be relevant to many different organization members, not just managers.

ties within and outside their firm, and cognition which refers to individuals' mental models and beliefs. Differences in these factors may affect how individuals make decisions and deploy dynamic capabilities. With regard to human capital, for example, prior empirical innovation research has shown that individuals characterized by a wide range of knowledge and diverse interests heavily engage in sensing and seizing activities (Howell & Shea, 2001).

Considering social capital, the extant work has revealed that greater diversity and density of individuals' personal networks improve individuals' abilities in sensing and seizing (Mors, 2010; Rodan & Galunic, 2004). With respect to cognition, innovation research has highlighted that individuals' perception of a firm's technological environment influences the firm's sensing and reconfiguring capacities (Eggers & Kaplan, 2009). In addition, I find that individuals' cognitive styles and their belief in being able to influence their environment determine their behavior related to sensing and seizing (Howell & Shea, 2001; Miron-Spektor et al., 2011). Taken together, these findings emphasize the critical role of the microfoundations of dynamic capabilities (Felin & Foss, 2005; Foss, 2011; Gavetti, 2005), and they may provide a starting point for further research into this field.

Prior conceptual work has emphasized the role of teams in the development of dynamic capabilities (Helfat & Peteraf, 2003; Zollo & Winter, 2002) and deployment of dynamic capabilities (Eisenhardt & Martin, 2000). In the empirical innovation literature, I find three important *project and team-level antecedents* of dynamic capabilities-related activities: project management practices and team skills that support project teams in their sensing and seizing activities (Song et al., 1997), a high degree of autonomy of project teams that forms a favorable condition for the teams' sensing and seizing activities (Tatikonda & Montoya-Weiss, 2001), and shared mental models among team members that facilitate their collective sensing and seizing (Berchicci & Tucci, 2010). The latter may also embrace mental processes to change and shape a team's collective beliefs and routines which can be referred to as a team's capacity to reconfigure its own capabilities (Akgün et al., 2006). This finding supports Zollo and Winter's (2002) concept of capabilities evolution suggesting that the development of a capability can be triggered by a team's internal reflections about potential improvements of existing routines.

At the *organizational level*, Verona and Ravasi (2003) proposed four fundamental building blocks that determine dynamic capabilities: structures and systems, human resources, physical resources, and culture. Consistent with prior conceptual suggestions about organizational structures and systems (Eisenhardt & Martin, 2000; Helfat et al., 2007; Teece, 2007), my review

of empirical innovation research has shown that formalization, decentralization, and coordination mechanisms have significant effects on dynamic capabilities-related innovation activities. Although most of these elements are positively related to dynamic capabilities, the differing findings in the extant work regarding formalization suggest that depending on the specific object (e.g., the overall organization) or processes (e.g., product development process) that are meant to be formalized and according to the specific capacity under study, different degrees of formalization may be appropriate to effectively deploy dynamic capabilities (Jansen et al., 2006; Kleinschmidt et al., 2007; Leiponen, 2006). Therefore, the impact of formalization needs further investigation.

With regard to the management of human and physical resources, I find support for their relevance to dynamic capabilities-related activities; while investments in developing highly skilled employees help to build up knowledge, investments in physical infrastructures (e.g., databases) foster the storage and dissemination of knowledge (Subramaniam & Youndt, 2005). In line with Teece et al. (1997), I find empirical evidence that an organizational culture which is supportive for innovation may act as a *de facto* governance system and induce individuals' behaviors relevant to dynamic capabilities-related activities in innovation (Kleinschmidt et al., 2007).

Drawing on the dynamic capabilities perspective, Eisenhardt and Martin (2000) see alliances and acquisitions as important means to bring new resources into the firm and to reconfigure a firm's resources. Based on my review of the innovation literature, I have identified *antecedents at the interorganizational level* as potential drivers for interfirm-based dynamic capabilities-related activities. Regarding alliances, these drivers include the quality of the partnership, the technological distance and knowledge complementarity between collaborating firms, the focal firm's alliance experience, and the position the focal firm has in the network of relationships (Bierly et al., 2009; Fang, 2011; Gilsing et al., 2008; Sherwood & Covin, 2008). Regarding acquisitions, for example, acquiring firms that pursue technologies new and complementary to the focal firm's technology base represent a driver of dynamic capabilities (Makri et al., 2010; Rothaermel & Hess, 2007).

With regard to the *consequences of dynamic capabilities*, there is a debate in the literature about whether dynamic capabilities automatically lead to superior performance. On the one hand, some works see a direct or indirect link between dynamic capabilities and superior performance (Teece et al., 1997; Zott, 2003). On the other hand, some conceptual research argues that dynamic

capabilities do not necessarily lead to performance gains because the benefits of dynamic capabilities may depend on how well the resulting underlying processes work (Zahra et al., 2006) or whether resulting changes in the resource base are valuable (Helfat et al., 2007). The findings of the present review on innovation research are in line with the former view in that dynamic capabilities-related activities result in two different forms of performance outcomes: superior innovation performance and overall firm performance. Across all reviewed studies that deal with outcomes, this link is mostly found to be direct.

Consistent with prior research into the consequences of innovation activities (De Luca et al., 2010), I identify three different domains of innovation performance outcomes based on my review: (a) the market performance of a firm's new products in terms of market share, sales, product quality, or customer satisfaction, (b) the financial performance of a firm's new products determined by the new products' profitability, and (c) a firm's innovation output defined as the number of new products introduced ranging from exploitative (incremental) innovation to exploratory (radical) innovation, as the number of entries in new product markets, or as the perception of whether the firm's product development program has been successful. With regard to firm performance as the second outcome associated with dynamic capabilities-related activities, I find a firm's overall performance, revenues, market share, and profitability (e.g., return on investment, return on sales, return on assets), often in comparison to competitors, to be common measures.

Insights for Innovation Research

Despite the small number of studies dealing with the reconfiguration of innovation processes, these studies further advance innovation research because the extant literature on new product development has focused on activities related to sensing and seizing (cf. Brown & Eisenhardt, 1995).

My findings reveal different reconfiguring activities referring to different degrees of transformation in innovation processes. Organizational mechanisms to apply know-how gained in previous new product development projects to subsequent projects (Marsh & Stock, 2006) or changes of a product development team's routines (Akgün et al., 2006) may constitute small adaptations of innovation processes. In contrast, the acquisition of high-technology firms (Rothaermel & Hess, 2007) or the reorganization of business units (Karim, 2009) may exhibit major reconfigurations of new product development processes. As these reconfiguring activities

have a positive, in the case of reorganization a U-shaped, effect on innovation outcomes, I can support the argument that firms need to frequently adapt their innovation processes to benefit from innovation and maintain superior performance (Teece, 2007).

In line with the dynamic capabilities view (Eisenhardt & Martin, 2000; Zollo & Winter, 2002), some of the reviewed studies indicate that the evolution of new product development processes is path-dependent (Danneels, 2002; Rothaermel & Hess, 2007; Thrane, Blaabjerg, & Møller, 2010). This is because a firm's product history determines the firm's options for future product development activities and a firm tends to leverage those innovation processes in which it has built up some expertise. For example, intentional experiments carried out by individuals that recombine established innovation activities and subsequent managerial interventions that convert successful experiments into new or adapted innovation capabilities have been identified as path-dependent learning mechanisms that shape a firm's innovation processes (Salvato, 2009).

Taken together, the findings that the innovation processes themselves should be reconfigured and that these processes emerge from path-dependent learning mechanisms indicate how the dynamic capabilities view can contribute to innovation research. These insights might encourage future research in product development to address not only how firms attain innovation success at any given point in time, but also how they develop and reorganize their innovation processes over time.

2.6 SUGGESTIONS FOR FUTURE RESEARCH

Based on the literature review, several critical research deficits can be identified that provide opportunities for future research. Therefore, in the following, I present several research suggestions for theory development and testing that should help to further advance our understanding of dynamic capabilities in innovation. Naturally, these suggestions are not all-embracing but they point to, in my view, important theoretical propositions regarding the nature and role of reconfiguring, interrelations among multilevel antecedents, and the unfolding of the consequences of dynamic capabilities-related activities.

Nature and Role of Reconfiguring

The reviewed articles predominantly describe or conceptualize dynamic capabilities-related activities at the organizational level. While some of these studies seem to rely – either explicitly or implicitly – on capabilities-related constructs as latent, rather indirectly observable firm-level

abilities,⁴ many others reveal concrete dynamic capabilities-related innovation activities in terms of identifiable and observable firm-level processes and routines, as illustrated in Category 1 of the review. In this regard, particularly activities related to sensing and seizing capacities have been well described in empirical innovation studies, whereas reconfiguring capacity and related activities remain rather ill-defined in the literature, although this type of capacity seems to be at the core of a firm's dynamic capabilities (Teece, 2007). The few reviewed studies on reconfiguring almost entirely conceptualize this capacity and related activities at the organizational level and neglect *who* actually performs these activities; that is, they do not define reconfiguring in terms of acting micro-level entities, such as central decision-makers or a group of key organizational members (for an exception, see Salvato, 2009, and Eggers and Kaplan, 2009).

Although also relatively little work exists that conceptualizes sensing and seizing at the micro level, the negligence of actual micro-level actors when conceptualizing reconfiguring seems more problematic because, in contrast to sensing and seizing, reconfiguring is inherently hard to routinize in terms of firm-level processes (Teece, 2012). Activities related to reconfiguring resources, structures, and, more specifically, the innovation process most likely are conducted by a firm's top managers because these individuals are usually responsible for the orchestration of organizational assets and decide upon the strategic development of their firm (Castanias & Helfat, 1991; Kor & Mesko, 2013). Similarly, Teece (2012: 1397) acknowledges that "[a]lthough some elements of dynamic capabilities may be embedded in the organization, the capability for evaluating and prescribing changes to the configuration of assets (both within and external to the organization) rests on the shoulders of top management." This is in line with Eggers and Kaplan (2009, 2013), who argue that managerial attention and cognition are important constituent elements of the so-called dynamic managerial capabilities that are intended to modify the resource base of a firm (for definitions, see Adner and Helfat, 2003, and Helfat et al., 2007).

In a similar vein, Danneels (2011) has made an important contribution to dynamic capabilities research by developing the concept of resource cognition, which refers to the mental representation that managers possess of their firm's resources including their potential applications. Accordingly, the consideration of top managers' resource cognition in the

⁴ See, for instance, Rothaermel and Hess (2007), who use dynamic capabilities as an implicit explanation for the association of multilevel antecedents with innovation performance without actually measuring capabilities.

conceptualization of reconfiguring may help to explain managerial decision-making associated with the development of the resource base and the adaptation of innovation routines and, thus, eventually the renewal path a firm pursues. In sum, conceptualizing reconfiguring in terms of top managers' cognitive and behavioral activities, instead of defining them as latent abilities, such as higher-order capabilities that are difficult to measure and locate within the organization, may bring us closer to a more realistic understanding of dynamic capabilities in innovation. The works by Salvato (2009) and Eggers and Kaplan (2009) included in the present review provide initial ideas for undertaking such research efforts.

Research Suggestion 1: Research on DC in innovation should develop more concrete conceptualizations of reconfiguring in terms of top managers and their activities and abilities that underlie resource reconfiguration (i.e. in terms of those micro-level entities that actually act).

While some innovation studies have confirmed that dynamic capabilities can be understood as a multidimensional construct, research on how different dimensions or types of dynamic capabilities-related activities are intended to function in combination with one another has predominantly focused on the interrelation between activities corresponding to sensing and seizing (see especially Categories 1, 4, and 5). The results of these studies demonstrate the complementarity of a firm's sensing and seizing capacity and underscore the need to balance exploration and exploitation (March, 1991). However, interactions among all three capacities by also including reconfiguring have been relatively neglected in empirical research and hence constitute a promising avenue of future study. There are several possibilities to explain how reconfiguring might be interrelated with sensing and seizing. A firm's reconfiguring capacity can be triggered by sensing and seizing activities, for instance, in the form of new product development efforts, as the development of a new product might force organizations to rethink their innovation processes and the configuration of their resources (Nonaka & Yamanouchi, 1989). A firm's reconfiguring capacity might also mediate between its sensing and seizing capacities: When a firm identifies a new technological or market opportunity through its sensing activities, the firm first needs to reconfigure and adapt its seizing activities to be able to exploit the opportunity.

In general, without being continuously adapted and renewed by the firm's reconfiguring activities, sensing and seizing activities might be insufficient to sustain a competitive advantage

over time. This assumption corresponds to the idea that one dynamic capability, in this case reconfiguring, can alter another dynamic capability, in this case sensing or seizing (Helfat & Peteraf, 2003). However, the maximum level of reconfiguring might not equal its optimal level because this capacity may also come with specific organizational costs which could, at a certain point, be detrimental for sensing and seizing.⁵ For instance, too much reconfiguring (e.g., in very short intervals) may overstrain an organization. It can cause frustration, uncertainty, and decreased productivity among those employees who are in charge of sensing and seizing because they may continuously have to change the way they work and they may even feel that their position is threatened. Eventually, optimal interdependencies among all three capacities may lead to a sustained competitive advantage because three interdependent capacities appear more ambiguous to a firm's competitors than a single capacity and, thus, protect the firm from imitation (cf. Song, Droge, Hanvanich, & Calantone, 2005).

Research Suggestion 2A: Research on DC in innovation should clarify and empirically analyze how reconfiguring relates to sensing and seizing.

Research Suggestion 2B: Research on DC in innovation should identify the optimal level of reconfiguring by considering its benefits and costs (e.g., with respect to its impact on the adaption and alteration of sensing and seizing).

Interrelations among Multilevel Antecedents

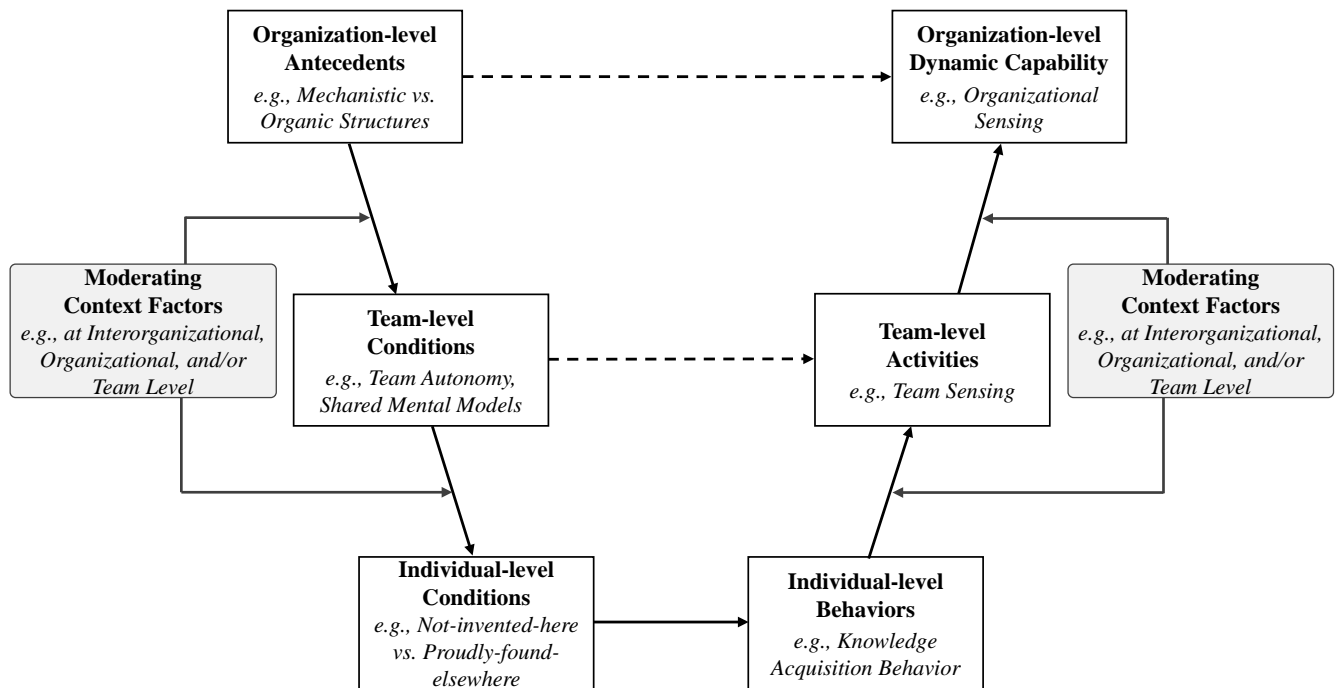
Although the present review has uncovered various antecedents at different levels of analysis, most studies have concentrated on only one level while disregarding other levels (e.g., the influence of team-level antecedents is analyzed on team-level dynamic capabilities-related activities). However, as previous theoretical work has argued (Felin & Foss, 2005; Felin & Hesterly, 2007), focusing on only one level implicitly suggests that most of the heterogeneity is situated at the focal level and that other levels are pretty much homogeneous or independent from the focal level. Recent empirical work on multilevel antecedents of dynamic capabilities has rejected these assumptions and shown that heterogeneity can lie across different levels (Rothaermel & Hess, 2007). Therefore, I encourage future researchers to undertake more multilevel studies in the fields of dynamic capabilities and capabilities-related innovation to

⁵ This observation is in line with Foss and Mahnke (2003), who acknowledge that knowledge-based research in general has ignored the conception of costs (as also cited in Volberda et al., 2010).

explore precisely how the antecedents at the different levels interrelate with one another in influencing firm-level capabilities. The revealed antecedents at the different levels may be helpful points of departure to launch such research endeavors. In general, two multilevel research strategies can be pursued, with the second building on the first.

First, future studies can adopt a *multilevel mediation analysis* to explain the formation of dynamic capabilities in innovation. As proposed in microfoundational work (Abell et al., 2008; Felin & Foss, 2005; Felin et al., 2015) such research efforts can draw on James Coleman’s (1990) model for macro-micro-macro-level interactions, known as Coleman’s bathtub or Coleman’s boat. Following this logic, relationships between organization-level antecedents and organization-level capabilities are mediated by the conditions and actions of individuals, which more realistically explain this relationship (Abell et al., 2008). In addition, adding the team level to Coleman’s model (cf. Minbaeva, Pedersen, Bjorkman, & Fey, 2014) would be worthwhile. Such a multilevel model is displayed in Figure 2.2 as an extension of the bathtub.

Figure 2.2: Extended Bathtub Model of Capability Formation



Note: Extended and modified from Minbaeva et al. (2014). The dashed lines symbolize explanatory shorthand relationships often taken for granted in past (uni-level) research on DC-related activities in innovation.

To give a concrete example of such multilevel explanations, we can take a closer look at the negative impact of mechanistic organizational design reflected by a high degree of centralization and formalization on a firm's sensing capacity, as found in the present literature review (e.g., Jansen et al., 2006; Song et al., 2011). This negative association may only serve as a simplification for what happens in teams and among individuals who actually carry out innovation-related activities. Although speculative and up to future empirical examinations, it is conceivable that a driver behind this finding is the so-called "not invented here" (NIH) syndrome among members of new product development teams. The NIH syndrome refers to individuals' tendency to trust more in knowledge they develop by themselves in-house than knowledge developed by outsiders, making them reluctant to embrace new ideas from external sources (Katz & Allen, 1982).

A mechanistic organizational design might affect individual-level NIH tendencies through its influence on the conditions of new product development teams. A high degree of centralization may give a team very little decision-making autonomy and a high degree of formalization may restrict a team's shared mental models toward a stronger company inward focus by overemphasizing the adherence to the firm's internal procedures and rules (cf. Damanpour, 1991). With lower decision-making autonomy, teams are to a much lesser extent empowered to engage in relationships with external parties (cf. de Jong, de Ruyter, & Lemmink, 2004) and with strong inward-focused shared mental models, external ideas or aspects of the environment may be perceived as disturbing (Katz & Allen, 1982). These team conditions may reinforce NIH tendencies among individual team members and, in turn, impede individuals' behaviors to acquire external knowledge. As a consequence, this can lead to lower levels of aggregated new knowledge that new product development teams can use to sense innovative solutions, which, as a result, constrains the firm's sensing capacity. Similar multilevel mediation models can be investigated with regard to the other antecedents and types of dynamic capabilities.

Research Suggestion 3: Research on DC in innovation should apply a multilevel mediation logic to understand the formation of dynamic capabilities; specifically, it should explore how relationships between organization-level antecedents and firm-level dynamic capabilities are mediated through micro-level processes involving team-level as well as individual-level conditions and actions.

Second, in complementing multilevel mediation models, future research can apply *multilevel moderated mediation analysis*. Such research efforts should aim to further increase our understanding of the movements from higher to lower levels (top-down) and from lower to higher levels (bottom-up) that can be referred to as “bridging laws” between levels (Volberda, Foss, & Lyles, 2010: 945). In so doing, we can investigate what and how context factors (e.g., at the interorganizational, organizational, or team level) moderate the relationships between antecedents at different levels as well as between antecedents and capabilities. Such moderation effects are visualized by the moderating context factors shown in Figure 2.2 and can be tentatively exemplified by drawing on selected antecedents identified in the literature review to serve as moderators.

With regard to top-down relationships, the reasoning in the example above implies that, in contrast to a mechanistic design, a rather organic organizational design reflected by high decentralization and low formalization would, through its effect on greater team autonomy and less inward-focused shared mental models, be conducive to reducing individual NIH tendencies. If we imagine the case of a new product development team that needs to collaborate with another organization to assimilate new knowledge, technological distance at the interorganizational level (i.e., between the focal firm and the partner organization) may serve as a context factor.

Technological distance may moderate the indirect, top-down relationship between an organic organizational design and the reduction of NIH tendencies among team members in such a way that the indirect impact through team conditions is enhanced when the partner organization is technologically more distant. In such a context, team members of the focal firm may perceive the partner’s knowledge as less competing and less threatening to their own personal status and competence because it belongs to a more distant technological domain than their own field of expertise.⁶ Thus, team members might be more open to acquiring and using this external knowledge (cf. Menon & Pfeffer, 2003; Menon, Thompson, & Hoon-Seok, 2006). In an extreme scenario, this can turn individuals’ tendencies from “not invented here” to “proudly found elsewhere” (cf. Huston & Sakkab, 2006).

With regard to the bottom-up formation of dynamic capabilities, a firm-level capability is more than just the sum of the conditions and behaviors of individuals and groups of individuals

⁶ This idea is similar to Menon et al. (2006), who argue for opposing status consequences of learning from external vs. internal rivals to explain why people are more willing to use external (distant) knowledge than internal (local) knowledge.

(Cohen & Levinthal, 1990; Gupta, Tesluk, & Taylor, 2007; Minbaeva et al., 2014). Mediation analysis of the influence of organizational design on firm capability through team-level and/or individual-level characteristics (as postulated above) will already offer important initial insights into how different levels interrelate to build a capability. In addition, research should put extra emphasis on the emergence part of the model itself (i.e., the right-hand part of Figure 2.2). That is, research should explore how context factors placed at levels higher than the individual level moderate bottom-up associations. Specifically, how do these factors shape a context that is supportive for the aggregation of individual contributions to the team level and then to the organizational level? For instance, the emergence from individual knowledge acquisition behavior to team-level sensing may be supported by setting common project goals – for example, set by the project team leader (identified in the present literature review as direct antecedent to project-level activities, e.g., Lynn et al., 1999). Project goals, ideally in accordance with the overall firm strategy, may help to coordinate and integrate individual actions towards joint team efforts (cf. Lindenberg & Foss, 2011); every individual must consider how he or she complements the behaviors of others in the team for the team as a whole to achieve its goals.

Another interesting bridge is that of team-level activities to firm-level capability. Here, the emergence of a firm-level dynamic capability from the activities of different teams (or more generally different organizational units) within the same organization might be supported, for instance, by interteam or interunit coordination mechanisms such as interteam committees or task forces composed of team members (e.g., team or department leaders) from different units (identified in the present literature review as direct antecedent to organization-level capacity, e.g., Mudambi et al., 2007). These mechanisms can enable organization-level synergies between knowledge acquired and generated by different teams and units and may help to explain what makes dynamic capabilities at the organizational level distinct from related activities and behaviors at lower levels of analysis. The contingent influence on bottom-up relationships that these and other similar implicit or explicit interunit and interemployee coordination mechanisms exert should be empirically tested in the future.

In sum, multilevel (moderated) mediation research will open up the black box of how multilevel origins function in combination to form dynamic capabilities and it is crucial to rule out alternative speculations about potential underlying micro-level mechanisms that we might erroneously assume when we only conduct pure organization-level analyses (cf. Minbaeva, 2013). Moreover, such work is especially appropriate when conceptualizing a dynamic capability

as a latent construct (e.g., Teece et al., 1997) because if the capability itself is not directly observable, it is at least necessary to know its determinants, that is, how a latent capability is built in terms of more manifest factors such as organizational design, team practices, and individual actions.

Research Suggestion 4A: Research on DC in innovation should examine in a multilevel mediation model of dynamic capabilities' formation how top-down relationships are moderated by context factors located at the interorganizational, organizational, and team level.

Research Suggestion 4B: Research on DC in innovation should examine in a multilevel mediation model of dynamic capabilities' formation how bottom-up relationships are moderated by context factors located at the interorganizational, organizational, and team level.

Of course, this kind of multilevel research encounters several methodological challenges in a large N setting. First and foremost, such research requires costly data sampling at least at two different levels of analysis, where lower level data units are nested in higher level data units. To obtain such data and to allow for some variability at each level, scholars can gather survey data in a hierarchical structure in several organizations.⁷ For instance, responses from several employees referring to the individual level should be nested within team leaders as key informants for the team level and the responses from several team leaders should be nested in top-level, senior managers as key informants for the organizational level (for similar approaches, see Nohe, Michaelis, Menges, Zhang, & Sonntag, 2013; Wood, Van Veldhoven, Croon, & de Menezes, 2012). In addition, such multilevel research efforts may use secondary employee-employer register data.

While the analysis of top-down effects is well-established in multilevel linear modeling (e.g., Hofmann, 1997), bottom-up effects are not feasible in traditional multilevel approaches, apart from simple aggregation (Croon & van Veldhoven, 2007). However, recent advancements in multilevel modeling – namely, multilevel structural equation modeling (Preacher et al., 2010) – make it possible to methodologically accommodate bottom-up effects and account for the overall multilevel mediation (i.e., macro-micro-macro relationships) in one analytical model (see also

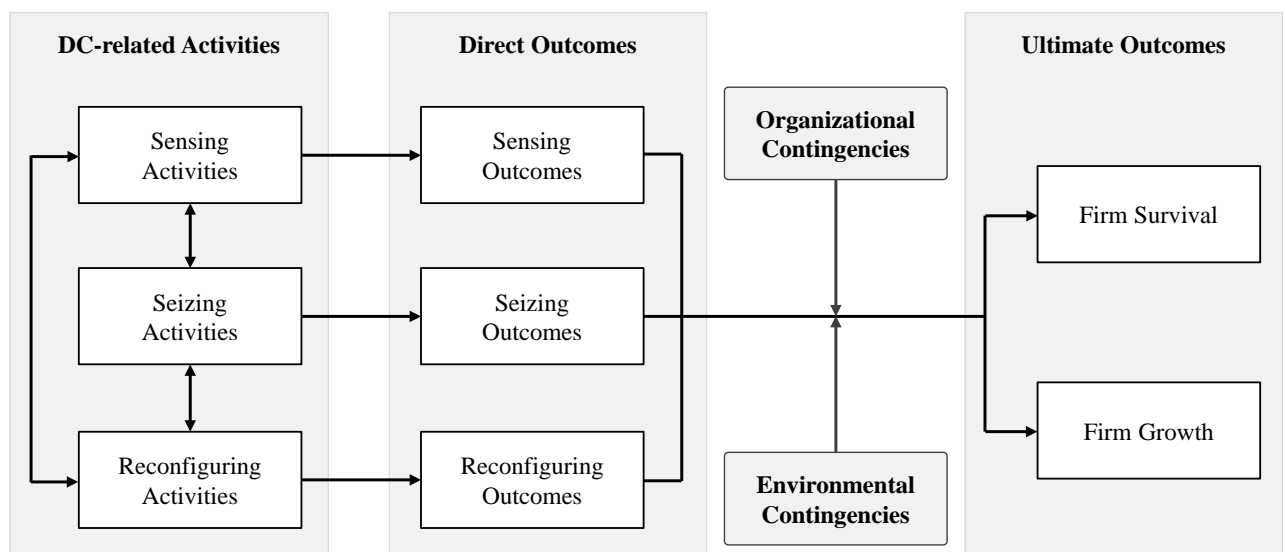
⁷ Recommendations regarding the required number of observations for the different levels and other statistical specifications can be found in Preacher et al. (2010).

Preacher, Zhang, & Zyphur, 2011). For the more complex specification of multilevel moderated mediation, one can refer, for example, to Wallace et al. (2016) and Shen and Benson (2016), who combine moderation analysis with multilevel structural equation modeling in the context of management research.

Unfolding of Performance Consequences

The studies in the review that deal with the consequences of dynamic capabilities-related innovation activities almost entirely relate these activities directly to two more general performance outcomes: innovation performance and firm performance. Such reasoning can be criticized for bordering on tautology in that if the firm owns a certain type (and amount) of dynamic capability, it must perform or innovate well (Arend & Bromiley, 2009; Zahra et al., 2006). To avoid tautological problems, future research on dynamic capabilities in innovation should first examine whether, according to their primary intention, dynamic capabilities lead to an alteration of the firm's resource base and then, in a second step, whether this alteration is successful in the long run (Helfat et al., 2007). Thus, as illustrated in Figure 2.3, the link between dynamic capabilities-related activities and (ultimate) firm performance should be unfolded and traced in more detail by considering what actually mediates the relationship and how it is positively or negatively affected by the context (cf. Helfat & Martin, 2015; Helfat & Peteraf, 2015). Accordingly, two important inquiries can be conducted in the future when tapping deeper into performance consequences.

Figure 2.3: Extended and Re-organized Model of Capabilities' Consequences



First, future work can explore what each single type of dynamic capabilities immediately causes in terms of alterations of a firm's resources or businesses – even if they constitute only moderate changes. The research should deal with the direct firm-level outcomes of sensing, seizing, and reconfiguring before testing effects on overall firm performance. Regarding sensing and seizing, as these types of activities are intended to recognize or generate new technological and market opportunities and then exploit them (Teece, 2007), future research can employ appropriate direct outcome metrics proposed in the entrepreneurship literature, where the concept of opportunity is well established (Short, Ketchen, Shook, & Ireland, 2010).

For instance, a direct sensing outcome might be measured as the total number of opportunities that have been recognized and created within a specific period of time by the firm (Shepherd & DeTienne, 2005). In line with Short et al. (2010: 55), opportunities can be operationalized as ideas that are “potentially lucrative” and may be specified regarding the actual domain of interest (e.g., market or technological opportunities). As a direct seizing outcome, for example, one may consider the total number of opportunities that have been successfully exploited by the firm. This can be specified within a specific time frame in terms of the number of new products or services introduced to the market (Pérez-Luño, Wiklund, & Cabrera, 2011) or new processes introduced to the firm's operations (Schilke, 2014). The strict distinction between direct sensing and seizing outcomes makes sense because not all potentially lucrative opportunities that are recognized are successfully exploited (Foss, Lyngsie, & Zahra, 2013).

Regarding reconfiguring, as this capacity is intended to reconfigure and renew resources, processes, and structures (Teece, 2007), direct outcomes can be measured by the number of reorganization events that have happened within a specific time frame within the firm (Karim, 2009; Salvato, 2009). Specifically, this can encompass, for example, the number of changes in organizational unit boundaries (e.g., acquisitions, splitting, merging or releasing of units), number of changes and modifications of innovation processes and activities (e.g., adding or removing process stages, adaptations of sensing and seizing activities), or number of leveraged resources (e.g., transfer and adaptation of existing market and technological resources to new fields of application).

For all three capacities, one may additionally account for the costs that capability formation and maintenance cause by dividing the direct outcomes of each capacity by the respective costs to obtain an efficiency measure for a capability. For instance, the costs for the formation of a firm's sensing capacity include costs of implementing organic organizational structures and recruiting

qualified research scientists. The potential costs of reconfiguring, as mentioned above in the discussion of the role of reconfiguring, should be emphasized again in this regard. Such an approach is consistent with Helfat et al. (2007: 7) and Teece's (2014: 332) conception of "technical fitness" to measure how well or poorly each capacity performs the task for which it is intended, regardless of whether it eventually results in overall firm performance in the long run.

In contrast, the long-term performance effects of dynamic capabilities might be captured by the notion of "evolutionary fitness" that corresponds to "how well a dynamic capability enables an organization to make a living" (Helfat et al., 2007: 7). The performance measures used by most of the reviewed innovation studies, such as the firm's innovative output, the new products' market performance, and financial performance metrics (e.g., return on investment), however, are less suited to fit this notion. The use of such typical, more static outcome indicators is prone to underestimating the value generated from resources and usually lacks a time dimension to address the dynamic facet of dynamic capabilities (Helfat et al., 2007).

Therefore, Helfat et al. (2007) proposed firm survival and firm growth as appropriate metrics for evolutionary fitness. Firm survival represents a clear indicator of whether a firm can adapt to its business ecosystem over time (on a minimum satisfactory scale) and can be measured in terms of the firm's financial solvency incorporating its probability to survive financially (Wilden, Gudergan, Nielsen, & Lings, 2013). Firm growth (e.g., in terms of revenues, number of employees or other metrics of size) indicates whether the firm tends to flourish over time (Helfat et al., 2007) and it may better capture whether a firm can not only adapt to but also shape its business ecosystem (Teece, 2007).

While the direct outcomes account for changes in the resource base induced by dynamic capabilities-related activities (and when divided by their costs assess the efficiency of capabilities), firm survival and growth as broader firm-level performance indicators refer to the ultimate outcomes of dynamic capabilities-related activities and assess their evolutionary fitness.⁸ Thus, the direct outcomes do not equal firm performance; rather, these outcomes are necessary but not sufficient to contribute to ultimate firm performance because the link between direct and ultimate outcomes depends on how effective the three capacities function in combination (as mentioned above) and on other factors (as discussed in the next paragraph).

⁸ To empirically establish causality, future research can measure DC-related activities, direct outcomes, and ultimate outcomes in a temporal order (e.g., with a time lag of three years, cf. Schilke, 2014).

Research Suggestion 5: Research on DC in innovation should unfold the consequences of dynamic capabilities by clearly disentangling DC-related activities from their direct outcomes and, subsequently, from their ultimate outcomes.

Second, future work should clarify when dynamic capabilities-related activities ensure firm survival and lead to superior firm growth and when they do not. As previous conceptual work has argued (Barreto, 2010; Helfat et al., 2007), the question of whether a firm realizes the potential of its dynamic capabilities might also be contingent on the context in which the firm and, more precisely, its capabilities operate. In other words, firms must align their dynamic capabilities-related activities with the external environment and the internal organization to benefit from such capabilities. This is denoted by the environmental and organizational contingencies shown in Figure 2.3.

The few innovation studies in this review that examined contingency effects on the activities-performance link predominantly focused on the external environment (e.g., Garg et al., 2003; Sidhu et al., 2007). For instance, sensing and seizing activities were found to be highly valuable in very dynamic environments because they enable firms to meet rapidly changing customer preferences, whereas in stable environments such activities may not adequately pay off because substantial shifts in customer needs are less likely to occur (Paladino, 2008).

In contrast, innovation research addressing internal factors that enable or impede the effective alignment of dynamic capabilities-related activities within the firm is very scarce. This observation is consistent with the extant, broader dynamic capabilities research where less is known about the precise organizational conditions that affect the performance effects of such capabilities (cf. Barreto, 2010; Helfat & Martin, 2015; Helfat & Peteraf, 2015). However, investigating organizational contingencies is as important as investigating environmental contingencies to better understand the consequences of dynamic capabilities. For example, Helfat and Peteraf (2015) compared IBM's successful transformation with Kodak's unsuccessful attempts to adapt to changes in their business environment. The authors questioned whether IBM's success was only attributable to its superior dynamic capabilities or whether Kodak perhaps possessed similar capabilities but faced an organizational context that hindered the firm from effectively deploying its capabilities.

It is conceivable that new strategic initiatives that have resulted from top management's reconfiguring activities fail to have the desired impact because the operative implementation of

these initiatives is hampered at lower levels within the firm due to certain organizational conditions. High levels of organizational formalization and routinization, for instance, may prevent employees from deviating from established behavioral patterns (cf. Hannan & Freeman, 1984). Employees may actively resist the adoption of new initiatives if changes in their routinized everyday work raise anxiety and uncertainty. In short, in addition to environmental factors, future studies can investigate what organizational contingencies enable, strengthen, or impede the performance of dynamic capabilities in innovation.

Research Suggestion 6: Research on DC in innovation should unfold the consequences of dynamic capabilities by considering the context in which DC-related activities operate; specifically, it should explore how organizational contingencies in addition to environmental contingencies moderate the link between direct and ultimate outcomes of DC-related activities.

2.7 CONCLUSION

My review has shown that important new insights and empirical evidence for the dynamic capabilities view can be gained from extant empirical studies in the field of innovation. Based on the review, I have developed an integrative framework that highlights the antecedents and outcomes of dynamic capabilities-related activities seeking to clarify conceptual foundations of dynamic capabilities. I have found that antecedents of dynamic capabilities-related activities originate at multiple levels of analysis. Furthermore, I have shown how different types of dynamic capabilities-related activities are interrelated and that these activities lead to superior innovation performance and firm performance. By revealing that the innovation processes themselves should be reconfigured, I have indicated how the dynamic capabilities view can contribute to innovation research.

Based on the deficits of the extant capabilities-based literature in innovation, I have offered several suggestions for future research that should help to advance our understanding of the nature, antecedents, and consequences of dynamic capabilities in innovation. I called for more concrete conceptualizations of reconfiguring in terms of those entities that actually act and for specifying the role of reconfiguring with respect to other capability types. I proposed applying a multilevel (moderated) mediation logic to explore how antecedents at the different levels interrelate with one another to form a dynamic capability. Moreover, I described how the link

between dynamic capabilities-related activities and (ultimate) firm performance should be unfolded by accounting for the direct outcomes that mediate the relationship and how the relationship is affected by the internal and external context. Accordingly, future studies can provide further important contributions to dynamic capabilities in innovation.

Appendix 2.1: Describing DC-related Activities (Category 1)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Alam (2003)	Case study of one large Australian manufacturing firm; Organizational and interorganizational level	Sensing	Monitoring consulting engineering firms and the marketplace are the basis for new product ideas. Ideas generated by consulting engineering firms are easily transferred to industrial firms if the involvement of engineering firms in the product development programs of industrial firms is intensive.
Amit & Zott (2001)	Case studies of 59 e-business firms; Organizational level	Seizing	A business model is needed to create value through the exploitation of business opportunities, whereby efficiency, complementarities, lock-in, and novelty are the main sources of value creation.
Athaide et al. (1996)	Survey of 242 high-technology firms; Organizational level	Seizing	Activities to commercialize innovations are among others: product customization, demonstration, trial, and training; information gathering on product performance; ongoing product support.
Chiesa & Fratini (2011)	Case studies of eight innovations of high-tech firms; Organizational level	Seizing	Commercialization activities include strategic decisions (e.g., about timing or positioning) and tactical decisions (e.g., about distribution, pricing or promotion) to achieve consumer acceptance of new high-tech products.
Craig (1996)	Case studies of 4 firms from the Japanese beer industry; Organizational level	Sensing, seizing, and reconfiguring	To cope with hypercompetition two types of capabilities are identified: 1) specialized capabilities to effectively carry out a particular task, e.g., new product development; 2) general capabilities to efficiently perform the continuous recombination and redeployment of resources.
Dahlander & Magnusson (2008)	Case studies of 4 Scandinavian open source software firms; Organizational level	Sensing, seizing, and reconfiguring	There are three means by which firms make use of open source software communities and their created knowledge: 1) accessing communities to extend the resource base; 2) assimilating communities in order to integrate and share results; 3) aligning firm strategies with the communities.
Danneels (2002)	Case studies of 5 high-tech firms producing business-to-business products; Organizational level	Sensing, seizing, and reconfiguring	Exploration and exploitation and three types of competences are identified: 1) first-order competences (customer and technological competences); 2) integrative competences to combine first-order competences; 3) second-order competences to build new first-order competences enabling organizational self-renewal.
De Brentani (1986)	Survey of 59 industrial product firms; Organizational level	Sensing	Dominant criteria for new product idea screening and selection are the idea's expected financial potential, its corporate synergy, its technological and production fit, and its differential advantage.
Demil & Lecocq (2010)	Case study of an English football club; Organizational level	Seizing	Business model evolution is revealed as a fine tuning process involving changes in and between core components of a firm's business model to continuously exploit business opportunities.
Felberg & DeMarco (1992)	Case study of a US chemical firm; Organizational level	Sensing	The new ideas generation process fulfills the following goals: employee involvement, business concept development, sponsored ideas, and cultural enrichment.
Filippaios et al. (2009)	Secondary data of 81 large MNCs in the food & beverage industry; Organizational level	Sensing and seizing	A global innovation strategy, which includes sourcing creative ideas from overseas R&D units, secures access to new knowledge and its implementation in new products. Knowledge creation is reflected by two types of foreign technological affiliates.
Gupta & Wilemon (1996)	Survey of 120 technology-based firms; Organizational level	Sensing and seizing	R&D capabilities with the highest importance for effective R&D are: understanding customer needs, observing market developments, and commercializing new technologies.
Harryson et al. (2008)	Case study of vehicle development including networks of several firms and actors; Interorganizational level	Sensing and seizing	Three types of development networks are identified: 1) open creativity networks focused on exploration; 2) closed process networks focused on exploitation; 3) transformation networks interlinking the two other networks.
Hart et al. (2003)	Survey of 166 managers from Dutch and UK industrial firms; Organizational level	Sensing and seizing	Along the new product development process important criteria include: technical feasibility and market potential during the early-screening phase; product performance, quality, and staying within the budget during the development phase; customer satisfaction and unit sales during the commercialization phase.
Hiennerth et al. (2011)	Case studies of three firms from diverse industries; Organizational level	Seizing	User-centric business models contain an adequate social software design, a clear intellectual property policy, proper incentive systems, evolutionary learning, and employee empowerment.

Appendix 2.1 (continued)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Iwamura and Jog (1991)	Survey of 43 investment firms from North America, UK, and Japan; Organizational level	Sensing	Innovative firms approach idea generation by employing a variety of idea sources, assigning a specific person or group, encouraging employee at all levels, using creativity techniques, non-monetary employee rewards, and group-level participation in evaluation decisions.
Karim and Mitchell (2004)	Case study of a large multinational healthcare firm; Organizational level	Reconfiguring	Innovation stems from sustaining a deep comprehension of organizationally-embedded routines, while undertaking a thorough continuous redefinition of unit and firm boundaries. Unit reconfiguration commonly precedes product line movement across unit boundaries.
Kodama (2005)	Case studies of 6 Japanese IT and multimedia firms; Interorganizational level	Sensing and seizing	For the purpose of knowledge creation networked strategic communities are formed inside and outside the company.
Kodama (2009)	Case studies of 54 Japanese high-tech firms; Organizational & interorganizational level	Sensing and seizing	Knowledge is synthesized by the leaders of every community that enables to build new business models. Skillful coordination and collaboration around a firm's organizational boundaries renews its accumulated knowledge while integrating diverse knowledge form internal and external sources.
Kraushar (1968)	Case study of a leading Diesel engines producer; Organizational level	Sensing	Product planning is revealed as distinct department concerned with collecting, screening, and evaluating new product ideas.
Kristensson et al. (2004)	Experiment of 47 professional developers and users; Individual level	Sensing	Professional developers and advanced users create more easily realizable ideas, whereas ordinary users create significantly more original and valuable ideas.
Lilien et al. (2002)	Survey of development projects at a multi-industry firm; Project level	Sensing	Sales originated from lead user product idea projects are predicted to be on average more than eight times higher than from projects using traditional market research technique.
Majchrzak et al. (2004)	Case studies of six projects at the California Institute of Technology; Project level	Sensing	Three layers of search-and-evaluate activities are identified: 1) scanning the environment to identify possible ideas; 2) brief evaluations of ideas to decide if the idea is worth pursuing; 3) detailed analysis of the idea.
O'Connor and DeMartino (2006)	Cases studies of twelve large multinational firms from innovative industries; Organizational level	Sensing and seizing	Three components of a radical innovation capability are identified: 1) discovery that refers to the creation, recognition, and articulation of opportunities; 2) incubation that refers to converting opportunities into business proposals; 3) acceleration that focuses on building a predictable business.
Peltokorpi et al. (2007)	Case study of a Japanese telecommunications firm; Organizational level	Sensing and seizing	An interlinked system of shared contexts facilitates the combination and open transfer of diverse knowledge and led to the commercialization of a new mobile Internet uniting novel technologies and services.
Ruiz-Navarro (1998)	Case study of a Spanish shipyard; Organizational level	Reconfiguring	Reorganizing peripheral routines and developing complementary resources, represents a fundamental method of continuous renewal of core competencies of a complex organization.
Salvato (2009)	Case study of a leading firm in designing home furnishing; Individual and organizational level	Reconfiguring	Mindful microactivities from individuals within and around the organization shape the content and adaptation of product development processes and timely managerial interventions shape organizational renewal by converting successful everyday experiments into new or adapted organizational capabilities.
Snow et al. (2010)	Case study of an innovation network; Interorganizational level	Sensing and seizing	In a collaborative community of firms institutional mechanisms support interfirm activities in R&D and commercialization of new products.
Söderquist (2006)	Case studies of 12 global manufacturing firms; Organizational level	Sensing and seizing	Three organizational structures for knowledge creation and sharing are identified: 1) a central strategic function; 2) internal to individual projects; 3) specialized functional departments.

Appendix 2.1 (continued)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Sosna et al. (2010)	Case study of a Spanish dietary products firm; Organizational level	Sensing	The concept of business model innovation is revealed as an initial experiment followed by constant revision, adaptation and fine tuning based on trial-and-error learning to continuously exploit business opportunities.
Spanjol et al. (2011)	Survey of 182 marketing and technical managers; Organizational level	Sensing	An emphasis on market search behavior, especially when focusing on competitors, is an important means to generate new product ideas.
Taylor (2010)	Case study of 4 information technology firms; Organizational level	Sensing and seizing	Internal competition from new development projects is applied to forcing product development groups using an existing technology to implement a new technology into the future generation of their products.
Thrane et al. (2010)	Case study of a Northern European medical device firm; Organizational level	Reconfiguring	The path dependency of innovation processes is revealed and specified by showing that firms may simultaneously break existing technological paths by creating new technological and market competences, while at the same time they may be cognitively locked-in to an innovation approach.
Tripsas (1997)	Case study of a leading typesetter firm; Organizational level	Sensing and seizing	Two key contributors to dynamic technical capability are identified: 1) external integrative capability to develop absorptive capacity; 2) geographically distributed research sites as a source of variation.
Verganti (1999)	Case studies of 18 Italian and Swedish firms from diverse industries; Organizational level	Sensing and seizing	To manage early phases of product development, firms use anticipation capabilities (systematic learning, team working, communication, and proactive thinking) and reaction capabilities (flexibility of resources, communication, overlapped development activities, and redundancies).
Veryzer, Jr. (1998)	Case studies of 8 product development projects from industrial and consumer product firms; Project level	Sensing and seizing	The new product development process starts with the dynamic drifting and convergence phase where exploration and evaluation of new technologies take place, followed by product application phases including the formulation of a product application, prototype testing, and commercialization activities.
Wood and Brown (1998)	Case study of a large Japanese electronics firm; Organizational level	Sensing and seizing	Technology development is divided into three stages: 1) appropriation involving monitoring, assessing, and capturing new technologies; 2) implementing knowledge to development; 3) manufacturing.
Zander (2002)	Case study of a leading automation firm; Organizational level	Sensing and seizing	Historical growth processes and firm-specific events constitute the ability to integrate and recombine knowledge within an international innovation network of dispersed technological capabilities.

Appendix 2.2: Antecedents' Influence on DC-related Activities (Category 2)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Berchicci & Tucci (2010)	Case study of a product development project in the mobility field; Team level	Sensing and seizing	Shared team values and beliefs influence the process through which a team acquires, implements and uses user information.
Björk & Magnusson (2009)	Secondary data from a Swedish firm; Individual and team level separately	Sensing	More social ties within an individual's personal network increases the generation of high-quality ideas. Regarding idea generation by teams, the amount of high-quality ideas grows with some increase in the connectivity of teams, but declines with a further increase in connectivity.
Branzi & Vertinsky (2006)	Secondary data of 1652 Canadian manufacturing SMEs; Organizational level	Sensing, seizing, and reconfiguring	Human resources development efforts improve acquisition, assimilation, and transformation capabilities; market and process development strategies improve assimilation capabilities; and product and market development strategies improve deployment capabilities.
Cohen & Levinthal (1990)	Survey & Secondary data of 318 American manufacturing firms; Organizational level	Sensing and seizing	R&D investments contribute to a firm's absorptive capacity that is the firm's ability of identifying and assimilating new external knowledge and applying it to commercial ends. Absorptive capacity is influenced by industry factors (e.g., competitor interdependence).
Frost & Zhou (2005)	Secondary data of 104 pharmaceuticals and automotive MNCs; Organizational level	Sensing and seizing	Joint R&D activities between subsidiaries in multinational firms enhance levels of absorptive capacity and social capital among participating subsidiaries and increase the likelihood that they will integrate knowledge in the future from each other.
Khurana & Rosenthal (1998)	Case studies of 18 business units from 12 US and Japanese firms; Organizational level	Sensing	Some firms rely on a formal new product development process to improve opportunity identification and assessment, idea generation, and concept planning. Other firms foster therefore a company-wide culture focused on business vision, technical feasibility, customer focus, schedule, resources, and coordination.
Laursen et al. (2010)	Secondary data of 352 firms; Organizational level	Sensing	The breadth of the firm's knowledge stock and the breadth of its prior monitoring activities impact technology exploration.
Lindgren & O'Connor (2011)	Case studies of development projects of two manufacturing firms; Project level	Sensing	Future-market focus of a project team influences the team's early stage activities such as concept generation, understanding of market needs, and idea screening.
Markham et al. (2010)	Survey of 272 Product Development & Management Association members; Organizational level	Sensing and seizing	Champions, sponsors, and gatekeepers are major organizational roles in the new product development process. Champions make the organization aware of new opportunities; sponsors promote the development of promising ideas and provide resources; gatekeepers establish decision criteria and seek acceptance for new projects.
Massini et al. (2002)	Secondary data of 775 Western and Japanese firms; Organizational level	Reconfiguring	High R&D intensity is strongly related with the adoption and adaptation of new organizational routines and processes.
McGrath (2001)	Survey of 56 projects of manufacturing, service and retail firms; Project level	Sensing	When the degree of exploration is high, organizational learning is more effective when the projects operate with autonomy regarding goals and supervision.
Mors (2010)	Survey of 79 senior partners in a global consulting firm; Individual level	Sensing	In homogeneous contexts, managers with less dense personal networks have a higher probability to create new knowledge, whereas in heterogeneous contexts, managers with very dense networks have a higher probability to create new knowledge.
Mudambi et al. (2007)	Survey and secondary data of 275 subsidiaries of MNCs; Organizational level	Sensing	Subsidiary self-determination on inputs and outputs as well as inter-team cooperation and intra-team cooperation are positively related to knowledge generation by subsidiaries.

Appendix 2.2 (continued)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Ordanini et al. (2008)	Case study of a music firm; Organizational level	Sensing and seizing	Project-based structures in new product development processes improve knowledge creation, retention, and transfer.
Persaud (2005)	Survey of 79 R&D units from Western and Japanese MNCs; Organizational level	Sensing and seizing	Autonomy, socialization, and a low level of formalization as well as intense communication between globally dispersed R&D units positively impact the ability of multinational firms to accumulate and exploit knowledge.
Pierz (1995)	Case study of a US telecommunications firm; Organizational level	Reconfiguring	Benchmarking methodology improves redesigning and redirecting the new product development organization.
Rodan & Galunic (2004)	Survey of 106 managers from Scandinavian telecommunications firms; Individual level	Sensing and seizing	A manager's creativity and effectiveness of implementing novel ideas is positively associated with the heterogeneity of knowledge present in his or her personal network.
Schulze & Hoegl (2008)	Survey of 94 projects of 33 German industrial firms; Organizational level	Sensing	Socialization and internalization are positively related to the novelty of product ideas, whereas externalization and combination are negatively related to the novelty of product ideas.
Sherwood & Covin (2008)	Survey of 104 industrial firms engaged in alliances with universities; Interorganizational level	Sensing	In alliances between industrial firms and universities partner trust, partner familiarity, and communications between the partners' technology experts predict successful knowledge acquisition.
Song et al. (2011)	Survey of 227 high-technology firms; Organizational level	Sensing and seizing	Formal strategic planning negatively affects new product development activities measured through the number of R&D projects undertaken.
Subramaniam (2006)	Survey of 57 product manufacturing MNCs; Organizational level	Seizing	Knowledge integration in multinational firms is effective through cross-national collaboration, but not through cross-national teams and cross-national communication.
Vaccaro et al. (2009)	Case studies of two projects from an automotive firm; Project level	Sensing and seizing	Information and communication technologies support the transfer and the creation of new explicit and tacit knowledge in new product development projects.
Van de Vrande et al. (2011)	Secondary data of 153 pharmaceutical firms; Organizational and interorganizational level	Sensing	Alliances positively affect the creation of completely novel technologies, whereas this effect is negative for mergers and acquisitions.
Vandermerwe (1987)	Survey of 100 executives involved in innovation; Organizational level	Seizing	The technological distance between partnering firms positively influences the creation of novel technologies. Requisites for getting an idea diffused in-house are: presentation, selling ability and attitudes; finding and getting to power base; fit with strategy, technology, finance, marketing; track record of success.
Verona & Ravasi (2003)	Case study of a Danish hearing-aid firm; Organizational level	Sensing, seizing, and reconfiguring	Organizational structures and systems, human resources, physical resources, and culture influence the creation, absorption, integration, and reconfiguration of knowledge.

Appendix 2.3: DC-related Activities' Influence on Outcomes (Category 3)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Atuahene-Gima et al. (2005)	Survey of 175 US manufacturing firms; Organizational level	Sensing and seizing	Responsive market orientation has a U-shaped and proactive market orientation has an inverted U-shaped relationship with new product development performance.
Baker & Sinkula (2007)	Survey of 243 manufacturing and consumer product firms; Organizational level	Sensing and seizing	Market orientation is positively related to new product development performance. Strong market orientation facilitates to balance incremental and radical innovation by shifting a firm's innovation focus more toward activities related to radical innovation.
Barczak (1995)	Survey of 140 telecommunications firms; Organizational level	Sensing and seizing	Idea generation and screening, customer prototype testing, concept definition and testing, and the presence of a product champion are crucial to the success of new product efforts.
Calantone et al. (2003)	Survey of 453 US firms from diverse industries; Organizational level	Sensing and seizing	Market orientation is indirectly positively related to innovation performance through new product development speed and corporate strategic planning and moderated by environmental turbulence.
Calantone et al. (1995)	Survey of 65 firms from the furniture industry; Organizational level	Seizing	Product introduction activities to rapidly introducing large numbers of product improvements or completely new products are positively related to firm performance.
Cooper & Kleinschmidt (1993)	Survey of 123 industrial firms from North America and Europe; Organizational level	Sensing and seizing	The quality of pre-development activities, an early product definition, a strong market orientation, and the quality of technological and production activities are key success determinants of new product development.
Davis & Eisenhardt (2011)	Case studies of eight technology collaborations; Interorganizational level	Reconfiguring	Rotating leadership between collaborating firms in joint technology development acts as a recombination mechanism in the organization of collaborative innovation and may lead to innovation performance.
De Luca et al. (2010)	Survey of 50 Italian biotech firms; Organizational level	Sensing and seizing	Market orientation has a strong positive relationship with firm performance when this relationship is mediated by R&D effectiveness. The different dimensions of market orientation have different influences on R&D effectiveness.
Di Benedetto (1999)	Survey of 183 Product Development & Management Association members; Organizational level	Seizing	Key determinants for successful product innovation are high-quality development and commercialization activities such as superior marketing and selling efforts, cross-functional teams, technical support for customers, excellent launch timing, and customer feedback integration.
Frenz & Letto-Gillies (2009)	Secondary data of 679 UK firms; Organizational level	Sensing	Internal knowledge generation and external knowledge acquisition are positively related to new product development performance.
Frishammar & Hörte (2005)	Survey of 206 Swedish medium-sized manufacturing firms; Organizational level	Sensing and seizing	Scanning the technological environment, decision-making based on information from the environment, and cross-functional collaboration are positively related to innovation performance. Scanning customers, suppliers, and competitors is negatively related to innovation performance.
Garg et al. (2003)	Survey of 105 single-business manufacturing firms; Individual and organizational level	Sensing	In dynamic environments, increased CEO emphasis on scanning task sectors of the environment (e.g., technology) and on innovation-related internal functions are related to higher firm performance. In stable environments, increased CEO emphasis on scanning general environmental sectors (e.g., sociocultural) and on efficiency-related internal functions are related to higher firm performance.
Grimpe & Kaiser (2010)	Secondary data of 3966 German innovative firms; Organizational level	Sensing	External knowledge acquisition through R&D outsourcing has an inverse U-shaped relationship with innovation performance that is positively moderated by internal R&D and the breadth of R&D collaborations.
Iansiti & Clark (1994)	Survey of 56 projects in the automobile and computer industry; Organizational level	Sensing and seizing	Customer integration (linking knowledge about future customers to the development process), technology integration (linking the evolving base of technological knowledge to the existing base), and internal integration (coordination between different specialized subunits) increase firm performance.

Appendix 2.3 (continued)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Ingenbleek et al. (2010)	Survey of 144 manufacturing and service firms; Organizational level	Sensing and seizing	Value-informed pricing has a mediating effect on the relationship between market orientation and innovation performance.
Kahn (2001)	Survey of 156 managers from textile and apparel firms; Organizational level	Sensing and seizing	Market orientation and interdepartmental integration are positively related to superior product development performance.
Karim (2009)	Secondary data of 250 healthcare firms; Organizational level	Reconfiguring	Reorganization has a U-shaped relationship with innovation, implying that firms need to experience several reorganization events until learning and innovation can occur.
Khan & Manopichetwattana (1989)	Survey of 50 small US manufacturing firms; Organizational level	Sensing	Environmental scanning is positively related to innovation.
Kim & Atuahene-Gima (2010)	Survey of 157 Chinese manufacturing firms; Organizational level	Sensing and seizing	Exploratory market learning (i.e. the acquisition and application of knowledge from beyond the firm's current market) and exploitative market learning (i.e. the acquisition and application of knowledge from the firm's current market) increase new product development performance.
Kusunoki et al. (1998)	Survey of 656 manufacturing firms in Japan; Organizational level	Sensing and seizing	Process capabilities (integrating different functions), local capabilities (accumulating technology) and architectural capabilities (linking individual knowledge) increase innovation performance.
Mishra et al. (1996)	Survey of 144 Korean firms; Organizational level	Sensing and seizing	Market intelligence and launch effort are positively related to new product success.
Phene et al. (2006)	Secondary Data of 87 US biotech firms; Organizational level	Sensing	Exploration of technologically distant knowledge of national origin has a curvilinear effect and exploration of technologically proximate knowledge of international origin has a positive effect on breakthrough innovation.
Sheremata (2002)	Survey of 33 projects from 23 software firms; Project level	Sensing and seizing	New product development projects that search to find problems and generate and integrate knowledge to solve problems are likely to attain their new product quality goals.
Sidhu et al. (2007)	Survey of 155 firms in the Dutch metal and electrical engineering industry; Organizational level	Sensing	Boundary-spanning supply-side search has a positive relationship with innovation in very dynamic environments, whereas boundary-spanning demand-side search has a positive relationship with innovation in less dynamic environments.
Song & Thieme (2009)	Survey of 315 projects of high-tech firms; Project level	Sensing and seizing	Spatial boundary-spanning contributes to innovation in more as well as in less dynamic environments. Supplier involvement in market intelligence gathering is positively associated with incremental innovations across predesign and commercialization activities and with radical innovations only during commercialization activities.
Talke & Hultink (2010)	Survey of 113 projects of German industrial firms; Project level	Seizing	Launch activities to lower diffusion barriers of new products related to customers, suppliers, and other stakeholders positively affect the new products' market success.
Van Riel et al. (2004)	Survey of 251 projects from Western and Japanese firms; Organizational level	Sensing and seizing	Market orientation mediated by an organizational climate favorable to information sharing as well as proactive knowledge updating is positively related to innovation performance.
Zhou & Wu (2010)	Survey of 192 Chinese High-technology firms; Organizational level	Sensing and seizing	A firm's technological capability (i.e. acquiring and employing various technologies) has a positive relationship with exploitative innovation and an inverted U-shaped relationship with explorative innovation.

Appendix 2.4: Relationships among Multiple DC-related Activities (Category 4)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Arbussa & Coenders (2007)	Secondary data of 3480 manufacturing and service firms; Organizational level	Sensing and seizing	Environmental scanning is related to R&D, technology acquisition, and downstream activities.
Fontana et al. (2006)	Secondary data of collaborations of 538 SMEs; Organizational and interorganizational level	Sensing and seizing	Searching, screening, and signaling activities of firms significantly affect the development of R&D collaborations with public research organizations.
Holmqvist (2004)	Case study of a Swedish software firm; Organizational level	Sensing and seizing	Exploitation generates exploration through an opening-up process and exploration generates exploitation through a focusing process.
Kauppi (2010)	Case study of a Finnish measurement products manufacturer; Organizational and interorganizational level	Sensing and seizing	Through specific organizational mechanisms a firm can integrate and balance its interorganizational exploration and exploitation partnerships.
Nonaka & Yamanouchi (1989)	Case study of a Japanese consumer electronics firm; Organizational level	Sensing, seizing, and reconfiguring	New product development activities serve as a catalyst for the self-renewal of an organization because they create a climate of turbulence and constructive conflict within the organization.

Appendix 2.5: Combination of Categories 2, 3, and 4 (Category 5)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Akgün et al. (2006)	Survey of 319 new product development teams from 45 firms; Team level	Seizing and reconfiguring	Shared cognitive processes such as team crisis and anxiety influence team unlearning, which refers to changes in team members' collective beliefs and routines, and in turn enhances the implementation of new knowledge and affects new product success.
Akgün et al. (2010)	Survey of 83 project teams of manufacturing firms; Team level	Sensing and seizing	Shared team culture values help to develop a procedural justice team climate, which positively affects team learning (creating, sharing, and implementing ideas), and in turn leads to new product success.
Atuahene-Gima (1995)	Survey of 275 manufacturing and services firms; Organizational level	Sensing and seizing	Market orientation positively affects new product development activities and in turn new product performance.
Atuahene-Gima & Wei (2011)	Survey of new product projects of 396 Chinese firms; Project level	Sensing and seizing	A firm's market knowledge competence (i.e. the acquisition and use of customer and competitor information) positively affects a firm's problem-solving competence (i.e. implementing creative solutions to problems), which in turn improves new product development performance.
Baker & Sinkula (2005)	Survey of 243 manufacturing and consumer product firms; Organizational level	Sensing and seizing	Market orientation is positively associated with new product success.
Cousins et al. (2011)	Survey of 111 manufacturing firms UK firms; Organizational level	Sensing and seizing	Market-orientation-inspired 'breakthrough' learning can negatively impact new product success if R&D and manufacturing are unable to implement the output of 'breakthrough' learning efforts.
Hammedi et al. (2011)	Survey of 126 top managers from international firms; Team level	Sensing and reconfiguring	Scanning the environment for breakthrough innovations leads to higher proficiency in R&D activities and knowledge sharing with suppliers, which in turn increase innovation and firm performance.
Henard & McFadyen (2005)	Secondary data of 106 leading R&D-oriented firms; Organizational level	Sensing and seizing	Transformational leadership and procedural rationality improve team reflexivity in new product screening (i.e. the evaluation and adaptation of screening methods), which in turn leads to more effective and efficient screening decisions.
Howell & Shea (2001)	Survey of 47 innovation projects and respective champions from manufacturing firms; Individual and project level	Sensing and seizing	Firms that engage in applied research activities (exploitation of stored knowledge) see enhanced performance returns from additional activities in basic research (general advancement of the stock of knowledge).
Kleinschmidt et al. (2007)	Survey of 387 global new product development programs; Organizational level	Sensing and seizing	A champion's breadth of knowledge and his belief to be able to influence the environment positively affect his environmental scanning efforts and his behavior of promoting new technologies in the organization, and this in turn positively predicts product development project performance.
Langerak et al. (2004)	Survey of 126 Dutch industrial firms; Organizational level	Sensing and seizing	Resource commitment, new product development process formality, a strong innovation culture and top-management involvement positively affect knowledge integration, homework activities, and launch preparation, which in turn lead to superior new product development performance.
Lynn et al. (1999)	Survey of 95 project teams from US high-tech firms; Team level	Sensing and seizing	Market orientation has a positive relationship with the proficiency in launch activities and this, in turn, increases new product performance and firm performance.
			Within-team learning practices (e.g. reviewing information, setting clear goals, pursuing a structured product development process) positively affect a project team's ability to acquire and implement new information, which in turn positively impacts the success of the new product project.

Appendix 2.5 (continued)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Marsh & Stock (2006)	Survey of 79 firms from different industries; Organizational level	Reconfiguring	Activities for retaining and interpreting information enhance the application of know-how gained in previous product development projects to subsequent projects, which in turn improves innovation performance.
Morgan & Berthon (2008)	Survey of 160 bioscience firms in the UK; Organizational level	Sensing and seizing	Market orientation that results in exploitative innovation strategy and generative learning that results in explorative innovation strategy are positively related and both, in turn, increase firm performance.
Paladino (2007)	Survey of 249 executives from top-performing firms; Organizational level	Sensing and seizing	Organizational learning that refers to the development of new knowledge is strongly related to market orientation, which in turn impacts different performance outcomes.
Paladino (2008)	Survey of 211 executives from top-performing firms; Organizational level	Sensing and seizing	Organizational learning is positively associated with both resource and market orientation, which in turn impact different performance outcomes moderated by market and technological turbulence.
Rothaermel & Deeds (2004)	Secondary data of 325 biotech firms and their alliances; Organizational & interorganizational level	Sensing and seizing	Exploration alliances lead to products in development, which in turn result in exploitation alliances, and exploitation alliances predict new products on the market.
Song et al. (1997)	Survey of 65 new product development projects from 17 Japanese high-tech firms; Project level	Sensing and seizing	Process and project management skills and their alignment with the project's needs positively influence marketing proficiency and product quality, which in turn lead to new product project performance. Team skills and design sensitivity positively influence technical proficiency.
Talke et al. (2011)	Survey and secondary data of 106 manufacturing firms; Team and organizational level	Sensing and seizing	Top management team diversity positively affects a firm's strategic innovation orientation (market orientation and technology orientation), which in turn increases innovation and firm performance.
Wei & Morgan (2004)	Survey of 110 Chinese manufacturing firms; Organizational level	Sensing and seizing	The supportiveness of organizational climate is positively related to market orientation, which in turn is positively related to new product development performance.
Yli-Renko et al. (2001)	Survey of 180 technology-based firms in the UK; Organizational and interorganizational level	Sensing	Social interaction with a key customer and the key customer's network ties, which give access to other customers, increase knowledge acquisition, and this, in turn, leads to new product development performance, technological distinctiveness, and sales cost efficiency.

Appendix 2.6: Antecedents' Direct Influence on Outcomes (Category 6)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Benner (2009)	Secondary data of 19 firms in the photography industry; Organizational level	Seizing	Process management methods based on ISO 9000 quality program certifications to exploit existing technologies are related with less responsiveness to technological change in terms of introducing new digital products.
Benner & Tushman (2002)	Secondary data of 115 firms in the paint and photography industry; Organizational level	Sensing and seizing	Process management methods based on ISO 9000 quality program certifications have a positive effect on exploitative innovation, but a negative effect on exploratory innovation.
Bierly et al. (2009)	Survey and secondary data of 180 US industry firms; Organizational and interorganizational level	Sensing and seizing	Technological relatedness between industry firms and university research centers is negatively related to explorative innovation outcomes. Prior experience with university research centers is a strong predictor for external knowledge application to innovation when the knowledge is more explicit.
Brettel et al. (2011)	Survey of 118 development projects from German firms; Project level	Seizing	The integration between R&D and marketing as well as between R&D and manufacturing positively influences new product development efficiency. The integration between marketing and manufacturing can positively affect effectiveness.
Dayan & Di Benedetto (2011)	Survey of 155 Turkish firms; Team level	Sensing and seizing	Team intuition has an inverted U-shaped relationship with new product development performance for teams with high experience and low stress.
Dayan & Elbanna (2011)	Survey of 155 Turkish firms; Team level	Sensing and seizing	Team intuition, which is influenced by team member experience, transactive memory systems, team empowerment, decision importance, and decision motives, increases new product success.
Eggers & Kaplan (2009)	Secondary data of 26 firms from the fiber-optics industry; Individual and organizational level	Sensing and reconfiguring	CEO attention to an emerging technology and the affected industry is related to faster entry into the affected new technology market.
Fang (2011)	Survey of 117 high-tech alliances in China; Interorganizational level	Sensing and seizing	Context-specific managerial cognition impacts the extent and direction of strategic renewal.
Gilising et al. (2008)	Secondary data of 85 industry firms; Interorganizational level	Sensing	Complementary knowledge sets of partner firms positively affect innovation performance. This effect is positively moderated by new product development process interdependence between the partners.
Ginn & Rubenstein (1986)	Case studies of 61 projects of a major chemical firm; Project level	Seizing	The alliance network position, the technological distance between partners, and the network density positively affect explorative innovation.
Jansen et al. (2006)	Survey of 283 business units of a large European financial service firm; Organizational level	Sensing and seizing	Regarding the R&D-production interface, development projects with higher levels of interpersonal conflict and more superordinate goals tend to be more successful.
Knudsen (2007)	Secondary data of 557 manufacturing and services firms; Organizational and interorganizational level	Sensing and seizing	Formalization positively affects exploitative innovation, centralization negatively affects exploratory innovation, and connectedness within business units positively influences both exploratory and exploitative innovation.
Leiponen (2006)	Survey of 167 Finnish business service firms; Organizational level	Sensing and seizing	Relationships with universities and private research institutes at the research stage as well as sharing supplementary knowledge with external partners at both the research and the development stages of the new product development process have a positive effect on innovation performance. Tacit, less formal competences and routines are positively related to completely new service introductions, whereas explicit, codified procedures are positively related to service improvements.

Appendix 2.6 (continued)

Author(s)	Method and Level(s) of Analysis	Type(s) of DC-related activities	Key Findings Concerning DC-related Activities
Makri et al. (2010)	Secondary data of 95 high-tech M&As of firms in diverse industries; Organizational and interorganizational level	Sensing and reconfiguring	Complementarities in knowledge between acquiring and acquired firms positively affect post-merger invention outcomes. Complementarities in knowledge are suggested to enhance strategic renewal.
Miron-Spektor et al. (2011)	Survey of 41 teams in an R&D company; Individual and team level	Sensing and seizing	Different cognitive styles of team members have diverse effects on team innovation performance; creative and conformist members foster radical innovation, whereas attentive-to-detail members impede radical innovation.
Phelps (2010)	Secondary data of 77 telecommunications firms; Organizational and interorganizational level	Sensing	The technological diversity of a firm's collaboration partners is positively related to explorative innovation. The influence of diversity is enhanced by the network density among a firm's collaboration partners.
Reid & De Brentani (2010)	Survey of 227 nanotechnology and materials firms; Organizational level	Sensing and seizing	Market visioning competence positively impacts market vision and each of these constructs positively impacts new product development performance.
Rothaermel & Hess (2007)	Secondary data of 81 pharmaceutical firms; Individual, organizational, and interorganizational level	Sensing, seizing, and reconfiguring	Antecedents of innovation are located across multiple levels of analysis and may have compensating or reinforcing effects on organizational-level innovation performance. Positive effects on innovation performance are found at the individual and at the interorganizational level.
Schulze & Hoegl (2006)	Survey of 94 projects of 33 German industrial firms; Organizational level	Sensing and seizing	Socialization during the concept phase and combination during the development phase positively affect new product development performance. Externalization during the concept phase as well as socialization and internalization during the development phase negatively affect new product development performance.
Song et al. (1998)	Survey of 236 managers of 16 Fortune 500 firms; Organizational level	Sensing and seizing	Firms using function-specific and stage-specific patterns of cross-functional integration during the new product development process stages are more likely to achieve higher new product success.
Souder et al. (1998)	Survey of 101 projects of 48 US and UK high-tech firms; Project level	Seizing	R&D-marketing integration and R&D-customer integration impact new product development effectiveness.
Subramaniam & Youndt (2005)	Survey and secondary data of 93 firms from different industries; Organizational level	Sensing and seizing	Organizational capital (storage of knowledge in physical repositories) is positively associated with incremental innovation, while human capital (employees' overall skills) interacts with social capital (connectedness within the firm and with external partners) to positively affect radical innovation.
Tatikonda & Montoya-Weiss (2001)	Survey of 120 new product development projects from different industries; Project level	Sensing and seizing	Project process formality, adaptability, and concurrency are associated with the achievement of operational project outcomes that, in turn, aids the achievement of market project outcomes.
Tushman et al. (2010)	Case studies of 13 business units; Organizational level	Sensing and seizing	Ambidextrous organization designs are relatively more effective in executing explorative and exploitative innovations than functional, cross-functional, and spinout designs.
Wadhwa & Kotha (2006)	Secondary data of 36 telecommunications firms; Organizational and interorganizational level	Sensing	When corporate investor involvement in investee firms is low, the number of corporate venture capital investments has an inverted U-shaped relationship with innovation performance. When corporate investor involvement is high, an increase in investments fosters innovation performance.

Chapter 3

Origins of Firm-Level Absorptive Capacity: Exploring Macro-Micro and Micro-Macro Relationships⁹

Abstract

Although the concept of absorptive capacity has gained wide acceptance in the literature, our understanding of the origins of a firm's ability to absorb and leverage new knowledge is limited. Following Coleman's (1990) bathtub framework for macro-micro-macro-level interactions in social science, this paper explores the multilevel antecedents of absorptive capacity. Survey data gathered at different levels of analysis in 106 medical technology firms indicate that formal and informal integration mechanisms are positively related to absorptive capacity at the organizational level and that this relationship is mediated through a micro-level process. The findings reveal that knowledge workers' cognitive process of perspective-taking and their creative behavior are important microfoundations of absorptive capacity. Moreover, the results emphasize the critical role of key employees in explaining firm-level heterogeneity in building organizational capabilities.

Keywords: absorptive capacity, microfoundations, multilevel analysis, organizational capabilities, perspective-taking.

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3.1 INTRODUCTION

To adapt to dynamic environments and achieve superior performance, firms are forced to generate new knowledge and innovate in terms of new products and services. In addition to creating new knowledge internally, firms' ability to absorb knowledge from external sources has become increasingly crucial. While some innovative firms, such as 3M and IDEO, seem to possess the necessary organizational characteristics and human resources to successfully capture value from external knowledge, many others fail (Foss, Laursen, & Pedersen, 2011; Henard & McFadyen, 2006; Lewin, Massini, & Carine, 2011). In attempting to explain such interfirm discrepancies, the concept of absorptive capacity, first defined by Cohen and Levinthal (1990: 128) as the "ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends", has evolved over the last decades (Mowery, Oxley, & Silverman, 1996; Tsai, 2001; Vasudeva & Anand, 2011; Zahra & George, 2002). Conceptualized as a dynamic organizational capability, absorptive capacity has gained wide acceptance in strategy and organization research (Lane et al., 2006; Lenox & King, 2004; Todorova & Durisin, 2007).

Despite the popularity of the concept, few empirical studies have tapped into the antecedents of absorptive capacity (Jansen et al., 2005; Schleimer & Pedersen, 2013). In particular, antecedents at the individual level have been relatively neglected in prior empirical work (Volberda et al., 2010). However, overlooking the importance of individuals in analyzing a firm's absorptive capacity is highly problematic because it diminishes their role as key assets of a firm and a fundamental locus of knowledge (Felin & Hesterly, 2007; Lane et al., 2006). In fact, abstracting from the impact of individuals would violate a core assumption of Cohen and Levinthal's (1990) original logic, according to which a firm's absorptive capacity depends highly on the cognitions and behaviors of its individual members. Moreover, prior empirical research has not sufficiently explored how a firm's absorptive capacity originates from formal and informal mechanisms at the organizational level and how these mechanisms are related to the individual level (Lane et al., 2006; Volberda et al., 2010).

Drawing on Coleman's (1990) bathtub framework for macro-micro-macro-level interactions, microfoundations research has provided a theoretical basis for handling this kind of question (Abell et al., 2008; Felin & Foss, 2005; Foss, Husted, & Michailova, 2010). Scholars have argued that organizational capabilities are rooted in the actions and interactions of

individuals and the organizational context to which individuals are exposed (Barney & Felin, 2013; Foss, 2011). However, the use of this framework has remained rather superficial without full application to specific firm capabilities, and challenges regarding how to accommodate the bathtub multilevel mediation in a large N setting may have hindered its empirical corroboration (Felin et al., 2015). Therefore, this paper seeks to tackle these challenges in the context of absorptive capacity and aims at answering the following research question: How do origins at multiple levels influence absorptive capacity?

Using survey data from top managers and core knowledge workers in 106 medical technology firms, this study contributes to the existing literature in several ways. First, I advance absorptive capacity research by conceptually identifying and empirically examining formal and informal integration mechanisms as important organizational antecedents of absorptive capacity. By showing that this relationship is mediated through a micro-level process including motivated cognition and creative behavior, I attempt to open up the black box of how a firm builds and deploys its absorptive capacity. In doing so, this study complements prior empirical work (Bierly et al., 2009; Jansen et al., 2005; Schleimer & Pedersen, 2013) and addresses three critical gaps in the literature on absorptive capacity (Volberda et al., 2010): It specifies the role of formal and informal organizational antecedents, reveals critical individual antecedents, and provides new theoretical arguments regarding how these antecedents are linked.

Second, I respond to calls for microfoundations of organizational capabilities (Felin & Foss, 2005; Felin et al., 2012). Specifically, I show that heterogeneity among firms' knowledge workers regarding their cognition and behavior accounts for heterogeneity of firm-level capabilities. Thus, the findings deepen our understanding of the impact of key employees in explaining inter-firm discrepancies in capability formation (Gavetti, 2005; Mäkelä, Sumelius, Höglund, & Ahlvik, 2012). Third, I contribute to research into perspective-taking (Boland & Tenkasi, 1995; Parker & Axtell, 2001) by identifying the cognitive process of perspective-taking as an important building block for organizational knowledge integration. I refine prior work (Litchfield & Gentry, 2010) and provide new insights into how perspective-taking is linked to absorptive capacity and how it can be influenced by organizational determinants.

Finally, this paper contributes to the microfoundations movement in strategy and organization research more generally (Felin et al., 2015), as it is among the first analyses that conceptually details and empirically validates Coleman's (1990) multilevel framework with respect to a specific firm capability. The study addresses the empirical challenges surrounding

microfoundational work by using data gathered at two different levels of analysis and applying multilevel structural equation modeling to account for both top-down (i.e., organization-individual) and bottom-up (i.e., individual-organization) relationships. Although this model of reciprocal macro-micro-level interactions has frequently been used to conceptually explain organizational phenomena (Abell et al., 2008; Felin & Foss, 2006; Foss et al., 2010), to date, empirical evidence of its existence has been limited.

3.2 THEORETICAL BACKGROUND

In line with previous work (Cohen & Levinthal, 1990; Lane et al., 2006; Lewin et al., 2011; Zahra & George, 2002), absorptive capacity is an organizational (dynamic) capability and multidimensional construct that might originate at multiple levels. Regarding its multidimensional nature, absorptive capacity has frequently been conceptualized with the four distinguishable dimensions of acquisition, assimilation, transformation, and exploitation (Jansen et al., 2005; Zahra & George, 2002). The first two dimensions jointly form potential absorptive capacity, which represents a firm's ability to acquire and understand new external knowledge, whereas the last two dimensions constitute realized absorptive capacity, which encompasses a firm's ability to leverage and apply the acquired knowledge (Jansen et al., 2005; Zahra & George, 2002). Although these two components of absorptive capacity and the four underlying dimensions have separate roles, they are complementary and highly interrelated to ensure that a firm successfully gains value from new external knowledge (Zahra & George, 2002).

In addition to its multidimensionality, absorptive capacity has a multilevel character (Lowik, Kraaijenbrink, & Groen, 2012), as it might be influenced by antecedents at different levels of analysis (Volberda et al., 2010). Previous conceptual work has started to highlight the different internal and external conditions under which absorptive capacity might evolve (e.g., Lane et al., 2006). At the organizational level, integration mechanisms in particular affect a firm's processes of absorbing and leveraging knowledge (Todorova & Durisin, 2007; Zahra & George, 2002). *Integration mechanisms* refer to those formal and informal mechanisms by which a firm coordinates its activities across and within its different organizational units (Zahra & Nielsen, 2002). These mechanisms form an internal firm environment beneficial to absorptive capacity by making a firm more receptive to new external knowledge and by enhancing knowledge exchange within its boundaries (Matusik, 2002). In a similar vein, Jansen et al. (2005) provided the first

empirical evidence of the impact of organizational mechanisms related to coordination and socialization capabilities on absorptive capacity.

However, the proposed direct association between integration mechanisms and absorptive capacity at the organizational level might only be a simplification of a more complex process at the level of organization members (cf. Abell et al., 2008; Felin & Foss, 2006). This assumption leads me to complement prior work by shedding additional light on the underlying individual-level drivers of absorptive capacity (i.e., its microfoundations). Following sociologist James Coleman (1990), explanations of macro-level phenomena that involve an analysis of their underlying micro-level processes may have more explanatory power than if the analysis remains only at the macro level. Such an approach is likely to be more accurate with respect to what actually happens at the micro level and may rule out alternative micro-level explanations of a certain macro-level phenomenon that a pure macro-level analysis might spuriously assume (cf. Minbaeva, 2013).

Based on this logic, Abell et al. (2008) and related works (Felin & Foss, 2006; Foss, 2007; Foss et al., 2010) adapted Coleman's (1990) bathtub framework on micro-macro levels in social science to organizational capabilities development. Thereby, these authors provided a theoretical basis for microfoundations and argued that links between organizational antecedents and organizational capabilities are mediated by the interplay of individual-level factors. In concrete terms, organizational antecedents influence the conditions of individuals' behaviors, which then, apart from other traits of the individuals, induce individuals' actual behaviors. In turn, these individual behaviors aggregate to the organizational level and determine organizational capabilities (Abell et al., 2008). To offer a microfoundational explanation of absorptive capacity, I propose an adaptation and specification of Coleman's (1990) framework with integration mechanisms representing the organizational antecedents and absorptive capacity the organizational capability.

In search of appropriate individual conditions and behaviors, I harken back to the original logic of the concept of absorptive capacity. According to Lane et al. (2006) and their reemphasis of Cohen and Levinthal's (1990) primary idea, "individual cognitions are the basis of a firm's absorptive capacity" (p. 857) and "it is the firm's individual members who add the creativity needed to help the firm uniquely create value from new knowledge" (p. 854). The *creative behavior* of employees is defined as their production of ideas that are new and valuable for the firm (Amabile, 1996; George & Zhou, 2001). In the sense of Cohen and Levinthal (1990) and

Lane et al. (2006), it is this individual behavior that enables a firm to make new associations never considered before and to leverage newly acquired knowledge.

To complete my specification of the Coleman model, I suggest that the cognitive process of *perspective-taking*, which refers to the adoption of other persons' viewpoints in trying to comprehend their needs and motives (Parker & Axtell, 2001), might be an adequate individual cognitive condition for several reasons. First, perspective-taking fosters creative behavior because it stimulates employees to think divergently and to attune to the preferences of others (e.g., customers, co-workers from other departments), that is, to create not only novel but also useful ideas (Grant & Berry, 2011). Second, perspective-taking is understood to be situationally motivated cognition (Litchfield & Gentry, 2010) and, thus, it is potentially malleable by organizational means that enhance employees' perception of different perspectives (Dougherty, 1992), such as integration mechanisms. Last, perspective-taking is highly relevant to a firm's absorptive capacity because it unlocks the potential of diverse external and internal knowledge (Hoever, van Knippenberg, van Ginkel, & Barkema, 2012). According to Litchfield and Gentry (2010), who preliminary linked perspective-taking to the concept of absorptive capacity, it also helps to convert diverse specialist knowledge into knowledge that can be used by all areas of the firm.

Theorizing about microfoundations of organizational capabilities implies disaggregating the analysis to the level of those individuals who might account for most of the heterogeneity at the organizational level (cf. Mäkelä et al., 2012). Regarding absorptive capacity, I suggest that a central locus of determinants resides among a firm's knowledge workers, such as research scientists, engineers, and marketing personnel (Smith, Collins, & Clark, 2005). These key employees are critical to new knowledge identification, creation, and exchange and, thus, are likely to have the greatest impact on the firm's innovation output and performance (Collins & Smith, 2006; Rothaermel & Hess, 2007). Therefore, I am interested in the condition and behavior of these employees, and they are the object of study at the micro level of the present multilevel analysis.

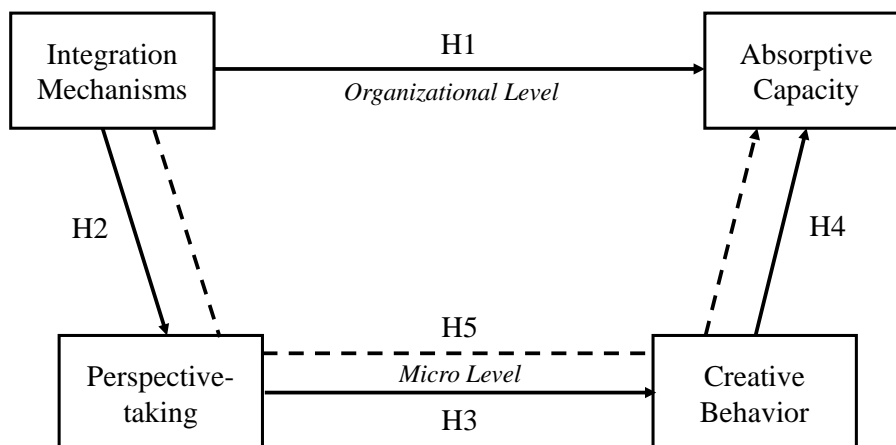
A few research efforts have been made to capture employee-related aspects of absorptive capacity, but they differ from the present study in significant ways. For instance, Minbaeva et al. (2003) emphasized employees' motivation and ability as important constituents of absorptive capacity, but measured employees' overall extent of these rather general characteristics without focusing on specific individuals. The early works by Tom Allen and Michael Tushman and

colleagues stressed the role of key individuals within an organization, such as gatekeepers and boundary-spanners, who acquire and translate external knowledge into something applicable for their firm (e.g., Allen & Cohen, 1969; Tushman, 1977; Tushman & Katz, 1980). However, these studies did not tap deeper into how differences in the detailed characteristics of these individuals account for firm-level heterogeneity. Ebers and Maurer (2014) investigated the impact of boundary-spanners' relational embeddedness and empowerment on a firm's absorptive capacity, but they did not consider how individual antecedents can be influenced by organizational mechanisms to provoke a concrete behavior. Overall, none of these studies has examined how the relationship between antecedents and absorptive capacity at the organizational level is mediated by cognitive and behavioral factors at the level of knowledge workers – a research gap that the present study addresses with data collected at both levels.

3.3 THEORETICAL MODEL AND HYPOTHESES

In the following, five hypotheses are developed that reflect the mediating role of knowledge workers' perspective-taking and creative behavior regarding the association between integration mechanisms and absorptive capacity. Figure 3.1 displays the theoretical model of this study, which illustrates the proposed specification of Coleman's (1990) bathtub and summarizes the hypotheses.

Figure 3.1: Theoretical Model



Note: Adapted from Coleman (1990) and Abell et al. (2008).

Organization-Level Relationships

Even though the focus in this study is on multilevel effects, the organization-level relationship between integration and absorptive capacity is initially considered as a baseline hypothesis, which will be unpacked by further hypotheses concerning cross-level and micro-level effects. Regarding potential absorptive capacity, many firms have established formal integration mechanisms such as liaison positions and cross-functional teams to enhance lateral communication and reciprocal information processing, thereby overcoming differences and enabling a better understanding of novel knowledge from external sources (Gilbert, 2006; Jansen et al., 2005).

In addition, Henderson (1994), for instance, has shown how pharmaceutical firms have used informal mechanisms such as social networks to explore new external technologies. By relying on the social relationships between different experts across different organizational units, these firms integrated a broad array of disciplines to make novel drug discoveries. While informal integration mechanisms maintain more flexibility in knowledge processes and, thus, are helpful in acquiring new knowledge (Burgers, Jansen, Van den Bosch, & Volberda, 2009), “formal mechanisms have the advantage of being more systematic” to ease the identification and interpretation of new trends (Zahra & George, 2002: 194).

Concerning realized absorptive capacity, firms use formal mechanisms such as cross-functional teams to integrate and combine diverse expertise coming from different functional areas such as research and development (R&D) and marketing and to foster the application of knowledge in new processes and products (Ordanini et al., 2008; Verona & Ravasi, 2003). Firms also rely on informal mechanisms to encourage trust and cooperation between different units, thus reducing conflicts regarding goals and interests and augmenting efficient knowledge exchange and implementation (Burgers et al., 2009; Jansen et al., 2005). Moreover, using informal means such as personal and open communication improves the richness of communication channels (Daft & Lengel, 1986). According to Hansen (1999), strong social relations within a firm are most beneficial when transferring and combining complex knowledge. Taken together, formal and informal integration mechanisms contribute to both components of absorptive capacity. Hence, I assume:

Hypothesis 1: Integration mechanisms are positively related to absorptive capacity.

Cross-Level and Micro-Level Relationships

In addition to their generally postulated impact on absorptive capacity, integration mechanisms may directly affect the conditions of individuals' behavior, such as the cognitive process associated with perspective-taking. As a well-established psychological concept, perspective-taking has been defined in the literature as a cognitive process through which an individual attempts to understand another person's preferences, values, motives, thoughts, and feelings by intentionally adopting the other person's viewpoint (Galinsky & Ku, 2004; Grant & Berry, 2011; Parker, Atkins, & Axtell, 2008; Parker & Axtell, 2001). Although perspective-taking is often assumed to be a stable disposition, which an individual possesses either by nature or by development (e.g., Davis, 1983), it is also widely acknowledged that the process of taking another's perspective is to a great degree contextually malleable (Parker et al., 2008). Perspective-taking also differs depending on how a specific situation is cognitively assessed (Parker & Axtell, 2001) and thus can be seen as situationally motivated cognition (Litchfield & Gentry, 2010). In the organizational context, perspective-taking is directed at firm-internal persons, such as colleagues, subordinates, and supervisors within the same unit and other departments, but also at firm-external persons belonging to the firm's customers, suppliers, and other stakeholders (Grant & Berry, 2011).

The extent to which employees engage in perspective-taking depends on organizational determinants such as job autonomy and hierarchical order because these factors influence the specific contexts and situations they face (Litchfield & Gentry, 2010; Parker & Axtell, 2001). Accordingly, formal integration mechanisms may determine the development of perspective-taking among a firm's knowledge workers, as these mechanisms expose employees to diverse perspectives and increase their perception of expertise in other functional units within the organization (Jansen et al., 2005). Through these mechanisms, employees develop an understanding of how their job is related to other functions or departments and how it corresponds to the organization as a whole. Such an integrated job understanding increases the likelihood of taking another's perspective (Parker & Axtell, 2001). Mohrman et al. (2001) revealed that perspective-taking between people with different functional backgrounds is facilitated by providing these people with formal forums where mutual reflection and learning can occur.

Formal mechanisms might be useful not only to take colleagues' perspective but also to get insights into the perspectives of external people with whom colleagues interact. For instance, by

taking the perspective of a salesperson, an engineer may also internalize the views of a customer so as to consider customer needs when designing a product (Dougherty, 1992). In addition, when a firm stresses informal mechanisms such as open communication and frequent social interaction in its operations, employees may build more interpersonal familiarity and personal affinity and, thus, be more likely to adopt another's viewpoint (Parker & Axtell, 2001; Sethi & Nicholson, 2001). In sum, both formal and informal integration mechanisms are potential drivers to develop perspective-taking among a firm's knowledge workers. Thus, I suggest:

Hypothesis 2: Integration mechanisms are positively related to knowledge workers' perspective-taking.

Cognitive processes are often the basis for tangible actions (Kaplan, 2011). Concerning perspective-taking, studies into the construct's behavioral outcomes have shown that taking the viewpoint of another person fosters socially integrative behaviors (Galinsky & Moskowitz, 2000; Parker & Axtell, 2001). In this regard, organizations which encourage perspective-taking among their knowledge workers may overcome the interpretive barriers to successful innovation caused by different thought worlds (Dougherty, 1992; Litchfield & Gentry, 2010). Different thought worlds reflect the different interpretive schemes within an organization that employees use to make sense of specific tasks (Dougherty, 1992). When these different schemata remain isolated, they can constrain joint learning (Boland & Tenkasi, 1995). However, when employees build on these differences through perspective-taking, both knowledge integration and innovation are facilitated (Dougherty, 1992; Litchfield & Gentry, 2010), implying that perspective-taking may stimulate individual creativity.

Prior empirical studies have examined the moderating role of perspective-taking in processes linked to individual creativity (Grant & Berry, 2011; Hoever et al., 2012). However, perspective-taking may also directly influence knowledge workers' creative behavior by addressing the two conditions that creativity has to fulfill per its definition: the creation of novel ideas and the creation of useful ideas (Oldham & Cummings, 1996). With regard to the novelty of ideas, considering the perspectives of others' stimulates individuals in the production of new ideas, as they are more able to combine, build on, and experiment with different viewpoints (Perry-Smith & Shalley, 2003). It also enhances individuals' divergent-thinking abilities (Ford, 1996): Seeing problems from others' perspectives enable individuals to ask new questions, apply

unusual interpretations, identify nonobvious associations and linkages, and create many alternative solutions to open problems.

Concerning the usefulness of ideas, taking other persons' perspectives may enable knowledge workers to transform novel ideas into ideas that are useful (Grant & Berry, 2011). After having generated several novel ideas, employees must select those that are most valuable and practical to others (Woodman, Sawyer, & Griffin, 1993). By taking numerous and different views of others into account, employees develop a detailed understanding of what ideas different stakeholders or colleagues may consensually regard as useful (Amabile, 1996). Thus, perspective-taking may serve as a filter for determining the usefulness of an idea (Boland & Tenkasi, 1995; Grant & Berry, 2011). Moreover, perspective-taking also facilitates a more constructive appraisal of others' ideas, thus fostering a reciprocal elaboration of each other's ideas to attain the highest possible usefulness (Hoever et al., 2012). Taken together, I expect:

Hypothesis 3: Knowledge workers' perspective-taking is positively related to their creative behavior.

Consistent with Felin and Foss' (2005, 2006) reasoning, a firm's absorptive capacity might be explained by its employees' creative behavior, permitting the firm as a whole to yield new knowledge combinations (Cohen & Levinthal, 1990) and to effectively realize value from newly absorbed knowledge (Lane et al., 2006). Relying on the two conditions that creative behavior has to fulfill per its definition, knowledge workers' ability to create novel ideas may be linked to potential absorptive capacity, while their ability to create useful ideas may be related to realized absorptive capacity.

As creativity involves the ability to think divergently (Ford, 1996), it contributes to potential absorptive capacity when employees make new associations and connect seemingly different external or internal information and elements that were isolated before (Amabile, 1996). By thinking 'outside the box', employees come up with multiple, entirely new ideas that may represent new solutions for problems or constitute potential business opportunities for their organization (Gaglio & Katz, 2001). The creative process is further reinforced because employees seek additional information to increase their own understanding of the new ideas generated (Tang, Kacmar, & Busenitz, 2012). By ascribing meaning to new associations and by relating them with previously held knowledge (Baron, 2006), employees improve the comprehension of new ideas for their organization, which lies at the core of a firm's assimilation capacity.

Regarding realized absorptive capacity, the emphasis is on the usefulness of new ideas for the organization and its stakeholders. While divergent thinking is crucial for the creation of a large number of novel ideas, it is not the key when it comes to the practicability of an idea (Woodman et al., 1993). Here, the ability to think convergently by relying on facts takes center stage to evaluate which of the new ideas is the most valuable and should be implemented (Basadur, Graen, & Green, 1982; Reiter-Palmon & Illies, 2004). Organizational transformation of knowledge may be achieved through employees' mutual creative act of reflective reframing. By questioning one another's original ideas and shifting the perception to new aspects of the problems to be solved, employees give adjusted or new meaning to original ideas, thus making them more appropriate for subsequent implementation (Hargadon & Bechky, 2006). For successful knowledge exploitation, employees' creative problem solving is necessary to considering possible obstacles to implementing ideas and matching the requirements for their application in new products or processes (Reiter-Palmon & Illies, 2004). Moreover, creative employees want their ideas to eventually pay off and, thus, also extensively engage in the realization of their ideas, e.g., by overcoming resistance to them (Sternberg, 2006). To sum up this reasoning, I propose:

Hypothesis 4: Knowledge workers' creative behavior is positively related to absorptive capacity.

Mediation Effect

In addition to the single effects hypothesized above, potential indirect relationships between the variables proposed must be taken into account to provide further arguments for the overall theoretical model of this study. For instance, integration mechanisms may only affect creative behavior through perspective-taking. Even when employees are given the opportunity to share knowledge by establishing integration mechanisms within the firm, idea creation is not automatically ensured (Hoever et al., 2012). Clashes among different perspectives may impede knowledge sharing and, thus, limit creative outcomes (Dougherty, 1992). Perspective-taking may avoid these problems by reducing the psychological isolation of people with different views and knowledge (Litchfield & Gentry, 2010) and by affecting how information to be exchanged is framed (Boland & Tenkasi, 1995).

Furthermore, perspective-taking may only affect absorptive capacity through creative behavior. Linking cognitive microfoundations such as perspective-taking to tangible behaviors is

essential, because without such relationship it remains unclear how and why cognitive processes lead to the formation of a firm capability (Litchfield & Gentry, 2010). It is through the employees' concrete behavior of producing new and valuable ideas that employees' cognitive conditions determine a firm's ability to absorb and leverage new knowledge (Lane et al., 2006). In sum, to the extent that a firm establishes integration mechanisms to coordinate its activities across and within its different organizational units, knowledge workers' perception of others' knowledge and of different perspectives is encouraged. Assuming that knowledge workers also engage in perspective-taking, their creative behavior will be leveraged as a consequence and, in turn, the firm's absorptive capacity will be enhanced (Cohen & Levinthal, 1990; Lane et al., 2006). Hence, I conclude:

Hypothesis 5: The positive relationship between integration mechanisms and absorptive capacity is sequentially mediated by knowledge workers' perspective-taking and creative behavior.

3.4 METHODS

Sample and Data Collection

As an exploratory pre-study, I conducted interviews with chief executive officers, heads of R&D, and innovation managers in 12 German high-tech firms. These interviews increased my understanding of which employees are involved in activities related to knowledge absorption and leveraging and how they are influenced by the organizational context. To test the study's hypotheses, a survey among firms from the German medical technology industry was set up. This setting was chosen because the German medical technology industry is a highly dynamic sector with short product lifecycles, a high rate of new inventions, and a heterogeneous technology structure. As the different technological areas in this industry converge and the pressure to innovate is high, medical technology firms strongly depend on new knowledge from external sources. Furthermore, the heterogeneity in technologies and product segments across firms in this sector allows for capturing sufficient variance in their absorptive capacity. For similar reasons, but with other national settings, this industry has also been the focus of prior studies (e.g., Karim, 2009; Kor, 2003).

To derive a representative sample, an initial list of the 600 largest firms by revenue that are assigned to the German industry classification codes for medical technology (WZ 266 and/or 325) was compiled from Creditreform, a comprehensive database listing companies located in Germany. From this list, I excluded pure trade companies and similar firms without an R&D or manufacturing function as well as firms that were not active in medical technology, although classified as such. This step was necessary to ensure the suitability of the sampled firms for this study and it resulted in a base sampling of 394 firms. To improve the response rate, the survey was promoted by two medical technology industry associations and advertised at two large industry trade fairs whose member firms highly overlap with the base sampling. Through these channels, 13 additional firms were included that were not on the initial list but fit the criteria of the target population. This yielded 407 relevant firms as the study's sampling frame.

To account for the multilevel design of my analysis and to limit common method variance in examining the relationships between the organizational and individual level (Podsakoff et al., 2003), I collected data from multiple informants at two different levels of analysis. For this purpose, I administered two different questionnaires: one with a focus on organization-level constructs and the other with a focus on individual-level constructs. These questionnaires were initially written in English, then translated into German, and finally back-translated. I conducted several pretests with R&D and innovation managers to eliminate any ambiguity concerning the wording of the questionnaire items.

For the organizational level, I first approached one key informant who had a detailed understanding of the organizational structures and mechanisms as well as of the knowledge-related capabilities of the firm. The exploratory interviews revealed that this was a member of the top management or another senior employee with a long firm tenure. For the individual level, I applied a procedure similar to Smith et al. (2005) and asked the first informant to identify two to three core knowledge workers. These are employees who are critical to the firm's knowledge creation and innovation processes and work closely with other knowledge workers (Collins & Smith, 2006; Smith et al., 2005). Thus, the core knowledge workers represent a good information source for the micro level.¹⁰

The multilevel structure of my examination furthermore required applying an adequate statistical method. I used multilevel structural equation modeling (SEM), which has specific

¹⁰ For a similar approach, see Gong et al. (2013) who empirically validated the use of core knowledge workers as an appropriate information source for the group of knowledge workers within a firm.

implications for data collection (Preacher et al., 2010). To allow for some variability within firms, I aimed to approach two to three core knowledge workers instead of only one. At first sight, the number of individual-level respondents may seem small compared to other multilevel studies (e.g., Shin, Kim, Lee, & Bian, 2012). However, for applying multilevel SEM, it is better to collect fewer micro-level entities for the benefit of collecting more macro-level entities (Hox & Maas, 2001; Meuleman & Billiet, 2009). Therefore, instead of augmenting the number of knowledge workers per firm, I concentrated on increasing the number of firms to ensure good performance of the estimation methods (Preacher et al., 2010).

The potential first informants were contacted by phone to obtain their consent. Those who agreed to participate were asked to name up to three core knowledge workers within their firm. Then, an email with the respective questionnaire and a personal letter ensuring confidentiality was sent to the first informant and the core knowledge workers. Those potential participants who did not respond in the first round were reminded by emails, postal letters, or follow-up phone calls. Of the 407 relevant firms, 345 were reached and 152 of these firms participated in the survey, yielding a response rate of 37 percent. Specifically, I obtained 148 questionnaires pertaining to the organizational level and 267 questionnaires pertaining to the individual level.

However, I received the minimum required number of respondents for each level for only 106 firms. Thus, regarding the organizational level, the final sample consisted of 106 key informants, mainly top and senior managers with an average firm tenure of 11.8 years. For the individual level, the final sample was composed of 236 core knowledge workers, corresponding to 82 firms with two and 24 firms with three core knowledge workers. Three firms provided more than the three requested core knowledge workers. Due to lack of informant qualification and to be consistent among firms and with the design of the study, these additionally received responses, four in total, were not considered. Most of the core knowledge workers (i.e., 72 percent) had an R&D function, while the remaining held positions in marketing (14%), product management (4%), or another functional area (10%). Knowledge workers had, on average, 9.4 years of firm experience.

The primary survey data were supplemented with secondary data for firm size, firm age and industry segments collected from company databases of the Bureau van Dijk and Hoppenstedt as well as other publicly available sources. The firms of the final sample had a median age of 34.5 years since founding (mean = 55, S.D. = 46.65) and median size of 216 employees (mean = 1261.9, S.D. = 5248.97). Most of the firms (i.e. 70 percent) were medium-sized, ranging from 50

to 500 employees. Thus, they were large enough to have established more formal organizational mechanisms. However, they were also small enough to ensure that the responding core knowledge workers had reliable insights into the characteristics of their colleagues (cf. Gong, Zhou, & Chang, 2013), since the group of knowledge workers in these firms was quite small compared to the total number of employees. These assumptions were supported by the exploratory interviews.

Furthermore, I investigated non-response-bias by comparing responding and nonresponding firms in terms of revenues and number of employees using information from the Creditreform database. I also checked whether early respondents and late respondents (i.e. respondents who completed the questionnaire after more than two weeks after being initially approached) differed regarding the study's central variables. In both cases, no significant differences ($p > 0.10$) were found between the groups.

Measurement and Validation of Constructs

To measure the different organization-level and individual-level constructs, I adapted multi-item scales from the extant literature, which are described in more detail in this section. Other scales used as control variables are shown in the Appendix of this chapter. All item-based measures were based on a 7-point Likert format on which 1 was strongly disagree and 7 was strongly agree. Their internal consistency was examined by calculating Cronbach's alpha. To evaluate the validity of the main constructs, I conducted several confirmatory factor analyses (CFA) with robust maximum-likelihood (MLR) estimation using the software package Mplus 7, which can handle multilevel data (Muthén & Muthén, 1998-2012). All items were loaded only on those factors reflecting the used measures for which they were a priori defined as indicators.

I assessed the *goodness of fit* of every CFA model by considering the chi-square value with degrees of freedom ($\chi^2[\text{df}]$), the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA). Based on the recommendations by Hox (2010), the CFI and TLI should be at least 0.90 for an acceptable model fit and 0.95 for a good model fit and the RMSEA should not exceed 0.08. Regarding *convergent validity*, the standardized factor loadings should be significant and above 0.50, the factors' composite reliabilities (CR) should exceed 0.60, and the average variances extracted (AVE) should be higher than 0.50 (Bagozzi & Phillips, 1982; Bagozzi & Yi, 1988; Hair, Black, Babin, & Anderson, 2010). Regarding *discriminant validity*, each factor's AVE should be larger than the

squared value of the correlations that this factor has with other factors in the same model (Fornell & Larcker, 1981).

Organization-level constructs. To measure integration mechanisms, I adapted existing scales of formal and informal integration from Zahra and Nielsen (2002). The four-item scale *formal integration* ($\alpha = 0.86$) reflects the extent to which a firm systematically coordinates its activities across different organizational and functional units. The four-item scale *informal integration* ($\alpha = 0.88$) captures the extent to which a firm relies on open communication and informal relationships within and across its organizational units. The items of both scales are displayed in Table 3.1 (including factor loadings and reliability values) further below. As all eight items of both scales jointly demonstrated a high degree of internal consistency ($\alpha = 0.88$), I computed a CFA with one second-order factor representing integration mechanisms that consisted of two first-order factors corresponding to formal and informal integration. For the model to be identified, both second-order factor loadings were fixed to one. This model fitted the data well ($\chi^2[19] = 28.85$, CFI = 0.97, TLI = 0.96, RMSEA = 0.07) and indicated a much better fit than a model with integration mechanisms as a first-order factor by loading all the items to only this factor ($\chi^2[20] = 130.08$, CFI = 0.68, TLI = 0.55, RMSEA = 0.23). Thus, I treated integration mechanisms as a second-order construct.

Absorptive capacity was operationalized with the four proposed dimensions (Zahra & George, 2002). I relied on existing measures for these dimensions (Jansen et al., 2005) and, in line with conceptual discussions in absorptive capacity research (Lane et al., 2006; Todorova & Durisin, 2007; Zahra & George, 2002), adapted these to firm-level characteristics and the study's industry setting. The three-item scale *acquisition* ($\alpha = 0.71$) addresses a firm's efforts to acquire new knowledge from external sources. The three-item scale *assimilation* ($\alpha = 0.84$) gauges a firm's proficiency in analyzing and understanding new external information. The four-item scale *transformation* ($\alpha = 0.82$) reflects the extent to which a firm is able to combine existing knowledge with new information and interpret existing knowledge in a new way. The four-item scale *exploitation* ($\alpha = 0.84$) assesses a firm's proficiency in exploiting new knowledge and applying technologies in new products. The overall absorptive capacity construct consisting of all 14 items showed a high internal consistency ($\alpha = 0.89$). These items are indicated below in Table 3.1.

To reflect the multidimensionality of absorptive capacity and the complementarity of its dimensions, I calculated a CFA model with absorptive capacity as a second-order factor containing four first-order factors pertaining to the four dimensions. This model had a satisfactory fit ($\chi^2[73] = 105.90$, CFI = 0.95, TLI = 0.93, RMSEA = 0.07) and fitted the data much better than a model with absorptive capacity as a first-order factor with all items treated as separate indicators ($\chi^2[77] = 258.37$, CFI = 0.70, TLI = 0.65, RMSEA = 0.15), providing empirical support to treat absorptive capacity as a second-order construct. I further examined the validity of all organization-level measures by performing an integrated CFA in which all single first-order factors of both constructs were correlated with one another. This model yielded a good fit to the data ($\chi^2[194] = 248.83$, CFI = 0.95, TLI = 0.94, RMSEA = 0.05) and, as shown in the Table 3.1, all measures fulfilled the criteria for convergent and discriminant validity postulated above.

Table 3.1: Results of Confirmatory Factor Analysis for Organization-Level Constructs

<i>Constructs and Items</i>	<i>Factor loading</i>	<i>t-value</i>	<i>CR</i>	<i>AVE</i>	<i>Corr²</i>
<i>Top and senior managers were asked to refer their answers to the whole organization.</i>					
Integration Mechanisms					
<i>Formal Integration</i> ($\alpha = 0.86$)			0.86	0.61	0.41
The activities of the different departments are tightly coordinated.	0.83	16.47			
The activities of the production and marketing/sales units are tightly coordinated.	0.81	14.65			
The activities of the R&D and marketing/sales units are tightly coordinated.	0.70	10.68			
The activities of the R&D and production units are tightly coordinated.	0.79	16.94			
<i>Informal Integration</i> ($\alpha = 0.88$)			0.88	0.65	0.41
Our firm maintains open communication channels in its operations.	0.66	7.58			
Our firm stresses informal relationships for realizing things.	0.87	25.70			
Our firm encourages free exchange of information.	0.86	21.15			
Our firm encourages informal communication, as needed.	0.82	13.57			

Note: n=106 observations (firms). Corr² indicates the highest squared correlation between the constructs.

Table 3.1 (continued)

<i>Constructs and Items</i>	<i>Factor loading</i>	<i>t-value</i>	<i>CR</i>	<i>AVE</i>	<i>Corr²</i>
<i>Top and senior managers were asked to refer their answers to the whole organization.</i>					
Absorptive Capacity					
<i>Acquisition</i> ($\alpha = 0.71$)			0.76	0.53	0.40
Our firm has frequent contact to other organizations to acquire new knowledge.	0.93	12.93			
Our firm organizes regular meetings with customers or other stakeholders to acquire new knowledge.	0.62	6.48			
We often access technological knowledge from external partners.	0.59	7.22			
<i>Assimilation</i> ($\alpha = 0.84$)			0.85	0.66	0.44
We are slow to recognize shifts in our market. (reverse-coded)	0.70	9.17			
New opportunities to serve our customers are quickly understood.	0.91	25.24			
We can quickly analyze and interpret changing market demands.	0.83	16.88			
<i>Transformation</i> ($\alpha = 0.82$)			0.84	0.57	0.34
We store technological knowledge for future uses.	0.61	8.43			
For new business opportunities we can resort to existing knowledge quickly.	0.91	22.15			
We communicate relevant knowledge across departmental boundaries.	0.73	10.10			
We are good at reactivating existing knowledge for new applications.	0.75	10.48			
<i>Exploitation</i> ($\alpha = 0.84$)			0.85	0.58	0.44
We constantly consider how we can better exploit technologies.	0.77	13.46			
We regularly combine new technologies with ideas for new products.	0.85	23.02			
It is easy for us to implement new technologies into new products.	0.69	10.64			
We are good at commercializing new technological knowledge.	0.73	13.48			

Note: $n=106$ observations (firms). Corr^2 indicates the highest squared correlation between the constructs.

Individual-level constructs. To measure attributes of all knowledge workers in every participating firm and to account for the entire within-firm variance, ideally, all of these employees would have been sampled (Felin et al., 2015). Each respondent would then rate how he or she perceives him or herself. However, due to the high costs associated with such an approach, I limited the data collection at the micro level to two to three core knowledge workers per firm and followed the referent shift model often used in multilevel work (Chan, 1998).

I derived an adapted form of the original constructs by switching the referent of the original items from self (“I” items) or a single employee (“he” or “she” items) to all knowledge workers (“our employees” items) while keeping the basic content and the original individual level of conceptualization of the constructs (Chan, 1998). Furthermore, an introductory text in the questionnaire explained the term knowledge workers and explicitly asked the respondents to refer their answers to only these specific employees. This approach allowed me to capture the entire group of knowledge workers, while at the same time considering within-firm variance in the respondents’ perceptions of the perspective-taking and creative behavior of themselves and their co-workers (cf. Preacher et al., 2010).

For *perspective-taking*, I adapted accordingly a four-item scale ($\alpha = 0.96$) developed by Grant and Berry (2011) which gauges the extent to which employees adopt other people’s perspectives and seek to understand their viewpoints. I measured *creative behavior* ($\alpha = 0.90$) with a 4-item scale, which was adapted from George and Zhou’s (2001) original 13-item scale. The scale mirrors the extent to which employees produce new and useful ideas to solve problems (see also Zhou & George, 2001). An integrated CFA with two correlated factors reflecting the items of perspective-taking and creative behavior, respectively, was run at the individual level in Mplus while controlling for the non-independence of observations within firms. This model demonstrated a satisfactory fit ($\chi^2[47] = 115.56$, CFI = 0.96, TLI = 0.95, RMSEA = 0.08) and the measures exhibited convergent and discriminant validity. The results of this CFA including the items of both scales, factor loadings, and reliability values are reported in Table 3.2.

Table 3.2: Results of Confirmatory Factor Analysis for Individual-Level Constructs

<i>Constructs and Items</i>	<i>Factor loading</i>	<i>t-value</i>	<i>CR</i>	<i>AVE</i>	<i>Corr²</i>
<i>Core knowledge workers were asked to refer their answers to those employees who are critical to knowledge creation and innovation (i.e. all knowledge workers).</i>					
Perspective-Taking ($\alpha = 0.96$)			0.96	0.86	0.36
Our employees frequently try to take other people's perspectives.	0.93	59.23			
Our employees make an effort to see the world through others' eyes.	0.97	95.72			
Our employees regularly seek to understand others' viewpoints.	0.85	26.49			
Our employees often put themselves in others' shoes.	0.96	87.26			
Creative Behavior ($\alpha = 0.90$)			0.90	0.70	0.36
Employees of our firm often suggest new ways to achieve goals.	0.73	17.45			
Our employees are a good source of creative ideas.	0.89	39.31			
Our employees develop creative solutions to problems.	0.90	32.19			
Our employees often pursue a fresh approach to problems.	0.82	23.93			

Note: $n=236$ observations (core knowledge workers). Corr^2 indicates the squared correlation between the constructs.

Control variables. Several control variables that may affect absorptive capacity at the organizational level were considered. I controlled for *firm size* by including the natural logarithm of a firm's total number of employees. I considered *firm age* by including the natural logarithm of the number of years from a firm's founding. As changing environments can provoke a firm to build absorptive capacity (Zahra & George, 2002), I controlled for *environmental dynamism* using a three-item scale ($\alpha = 0.83$). Furthermore, I included *decentralization* with a five-item reverse-coded scale of centralization of decision-making ($\alpha = 0.91$) and *formalization* with a four-item scale ($\alpha = 0.76$) that have been identified as organizational antecedents of absorptive capacity (Jansen et al., 2005; Schleimer & Pedersen, 2013). These scales were adapted from Jansen et al. (2006) and are shown in Appendix 3. At the individual level, I controlled for core knowledge workers' *firm tenure* in years and their *functional affiliation* using three dummy variables for marketing function, product management function, and other function, with R&D function as the reference category.

Analytical Procedures

Given the multilevel structure of the data, that is, several individual ratings of core knowledge workers nested within firms, I employed multilevel SEM to test the hypotheses using Mplus 7 (Muthén & Muthén, 1998-2012) and followed Preacher, Zyphur, and Zhang's (2010) recommendations for modeling multilevel mediation. This method has also been used in other recent studies (e.g., Den Hartog, Verburg, & Croon, 2013; Nohe et al., 2013; Sun, Zhang, Qi, & Chen, 2012; Wallace et al., 2016; Walsh, Matthews, Tuller, Parks, & McDonald, 2010) and it has two main advantages over traditional multilevel linear modeling, which are suitable for the present analysis.

First, multilevel SEM can account for bottom-up effects, that is, effects that are specified by individual-level independent variables predicting organization-level dependent variables (Preacher et al., 2010). Traditional multilevel modeling aggregates the individual-level variables to organization-level mean scores. The variances of the aggregated means then reflect both differences between firms and differences within firms, which may lead to misinterpretations (cf. Den Hartog et al., 2013). Multilevel SEM, however, prevents such problems of confounding both sources of variation by partitioning the variance of an individual-level variable into a within-level element (within-firm variance) and a between-level element (between-firm variance). Specifically, individual-level variables can be modeled with intercepts, which are permitted to differ across firms. These intercepts are defined as latent variables at the between level with individual respondents of each firm acting as indicators (cf. Walsh et al., 2010). These latent variables can be related to organization-level dependent variables, thus avoiding simple aggregation.

Second, multilevel SEM produces unbiased estimates of mediation effects (Preacher et al., 2010). In two-level mediation models, individual-level relationships usually have two parts: one part occurring at the between level and one part occurring at the within level. In traditional multilevel modeling, these two parts are conflated and the resulting mediation effect is biased if the effects at both levels are not identical (Preacher et al., 2010). In contrast, in multilevel SEM, individual-level relationships can be specified as between-level and within-level effects independently and simultaneously in one model. For the present analysis, the mediation effect can thus be computed more precisely as a pure between-level effect because two variables of the overall mediation model (i.e., integration mechanisms and absorptive capacity) vary only at the between level (i.e., between firms).

Because of the complexity of my multilevel analysis and the multidimensional measures at the organizational level, the number of parameters to be estimated compared to the number of observations is quite high (Bagozzi & Yi, 1988). To minimize the number of free parameters, I followed similar multilevel studies (Den Hartog et al., 2013; Sun et al., 2012) and computed the constructs' arithmetic means to be used in multilevel path analysis as a special form of multilevel SEM with only a structural model, but no measurement model.

To further justify the multilevel approach, I computed the intraclass correlation (ICC) for both individual-level variables (Klein et al., 2000). The ICC measures the extent to which ratings of individuals within the same firm differ from ratings of individuals in other firms. This parameter therefore represents the amount of variance in individuals' scores with respect to the firm (Klein et al., 2000). The ICCs for perspective taking and for creative behavior were 0.20 and 0.15, respectively, well above the suggested minimum value of 0.05 for applying multilevel SEM (Preacher et al., 2010).

Moreover, I assessed the model fit of the overall path model by considering the cutoff values for CFI, TLI and RMSEA that Hox (2010) recommended. To reduce (inessential) problems of multicollinearity (cf. Den Hartog et al., 2013), all variables were grand mean-centered except of the individual-level control variables, which were group mean-centered. All multilevel analyses were run using robust MLR estimation with robust standard errors (Muthén & Muthén, 1998-2012).

3.5 RESULTS

The descriptive statistics and the correlations among the study's relevant variables are displayed in Table 3.3. The highly significant correlations between formal and informal integration and between the four dimensions of absorptive capacity further justify combining these measures to second-order constructs of integration mechanisms and absorptive capacity. Integration mechanisms as an overall measure as well as formal integration and informal integration separately are positively and significantly correlated with each dimension of absorptive capacity and with the overall measure of absorptive capacity.

Table 3.3: Descriptive Statistics and Correlation

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Perspective-taking	4.12	1.17														
2. Creative behavior	4.95	1.04	0.56***													
3. Formal integration	4.64	1.13	0.18**	0.12 [†]												
4. Informal integration	5.07	1.06	0.15*	0.15*	0.52***											
5. Integration mechanisms	4.86	0.95	0.19**	0.15*	0.88***	0.86***										
6. Firm size	5.59	1.39	0.05	0.01	0.15	-0.01	0.08									
7. Firm age	3.65	0.86	0.01	-0.06	0.14	0.06	0.11	0.37***								
8. Environmental dynamism	4.58	1.31	0.18**	0.13*	0.33**	0.26**	0.34***	0.18 [†]	0.15							
9. Decentralization	5.06	1.37	0.13*	0.14*	-0.02	0.27**	0.14	-0.01	0.01	-0.02						
10. Formalization	4.85	1.32	0.00	0.06	0.32**	0.13	0.26**	0.26**	0.04	0.21*	-0.24*					
11. Acquisition	4.74	1.25	0.23***	0.25***	0.39***	0.34***	0.42***	0.23*	0.22*	0.32**	0.14	0.05				
12. Assimilation	4.96	1.24	0.23**	0.17**	0.39***	0.46***	0.48***	-0.02	-0.01	0.29**	0.19 [†]	-0.00	0.38***			
13. Transformation	5.25	0.98	0.23***	0.28***	0.41***	0.40***	0.46***	-0.01	-0.07	0.17 [†]	0.24*	0.03	0.34***	0.53***		
14. Exploitation	4.86	1.09	0.29***	0.24***	0.55***	0.54***	0.62***	0.10	0.13	0.43***	0.21*	0.01	0.56***	0.58***	0.53***	
15. Absorptive capacity	4.95	0.89	0.31***	0.30***	0.55***	0.55***	0.63***	0.10	0.10	0.39***	0.24*	0.03	0.75***	0.80***	0.74***	0.85***

Note: n = 106 for organization-level variables, n = 236 for individual-level variables. The correlations were estimated by using SPSS. For correlations between organization-level and individual variables, organization-level variables were disaggregated to each individual-level respondent. Control variables at the individual level are not shown in this table.

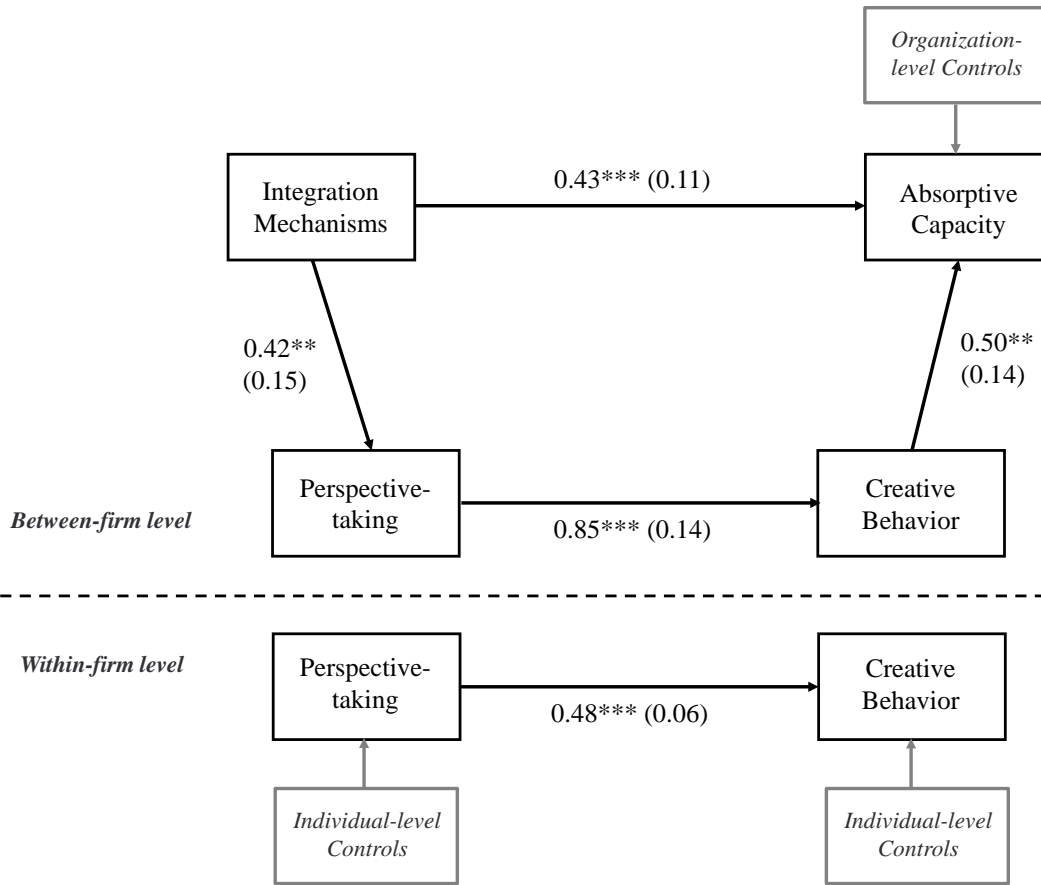
[†] $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Two-tailed tests.

Test of the Hypotheses

To test the hypotheses, I specified a two-level path model in Mplus that reflects the theoretical model of this paper. As the focus is two-level mediation, I followed the one-stage approach Croon and Van Veldhoven (2007) suggested, after which all direct and indirect pathways are estimated simultaneously in one model (cf. Den Hartog et al., 2013).

To account for the direct pathway, absorptive capacity was regressed on integration mechanisms. Concerning indirect pathways, perspective-taking was regressed on integration mechanisms, creative behavior was regressed on perspective-taking, and absorptive capacity was regressed on creative behavior. To control for alternative influences on absorptive capacity, the effects of the organization-level control variables on absorptive capacity were considered. All these relationships were specified at the between level in Mplus. In addition, the regression of creative behavior on perspective-taking was modeled at the within level because both variables can vary within firms. To control for characteristics of the responding knowledge workers, the individual-level controls were regressed on both perspective-taking and creative behavior at the within level.

Figure 3.2 shows the (standardized) results of the hypothesized two-level path model which fits the data well ($\chi^2[15] = 19.00$, CFI = 0.97, TLI = 0.94, RMSEA = 0.03). Regarding the effects of integration mechanisms, Hypotheses 1 and 2 are supported. Integration mechanisms are positively and significantly related to both absorptive capacity (0.43, $p < 0.001$) and perspective-taking (0.42, $p < 0.01$). Hypothesis 3 also is strongly supported because the relationship between perspective-taking and creative behavior is positive and significant at both the between level (0.85, $p < 0.001$) and the within level (0.48, $p < 0.01$). The findings also confirm Hypothesis 4, with creative behavior positively and significantly associated with absorptive capacity (0.50, $p < 0.01$).

Figure 3.2: Estimated Two-level Path Model

Note: Standardized coefficients with robust standard errors in parentheses. $n = 106$ for organization-level variables, $n = 236$ for individual-level variables. Effects of organization-level controls on absorptive capacity: firm size (0.05, $p > 0.10$), firm age (0.01, $p > 0.10$), environmental dynamism (0.18, $p < 0.05$), decentralization (0.08, $p > 0.10$), formalization (-0.17, $p < 0.05$). Effects of individual-level controls on perspective-taking: firm tenure (0.14, $p < 0.10$), marketing function (-0.03, $p > 0.10$), product management function (-0.12, $p < 0.10$), other function (-0.04, $p > 0.10$). Effects of individual-level controls on creative behavior: firm tenure (0.04, $p > 0.10$), marketing function (-0.09, $p > 0.10$), product management function (0.02, $p > 0.10$), other function (-0.08, $p > 0.10$). The missing data estimation technique in Mplus was used to handle missing values regarding firm tenure for $n = 9$ knowledge workers.

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$. Two-tailed tests.

With respect to Hypothesis 5 assuming a sequential mediation between integration mechanisms and absorptive capacity through perspective-taking and creative behavior, I considered the product term of the respective between-level coefficients which is, however, not normally distributed (Shrout & Bolger, 2002). To address this problem and test the significance of this product term, I applied a parametric bootstrap method with 20,000 Monte Carlo repetitions to compute a bias-corrected confidence interval (CI) around the indirect (mediation) effect by

using a special R-based web tool (Preacher & Selig, 2012; Selig & Preacher, 2008).¹¹ This procedure is particularly recommended when using multilevel SEM (Preacher et al., 2010) and indicates a positive and significant compound unstandardized coefficient for the indirect effect (0.16, $p < 0.05$) because the 95% CI (0.011, 0.425) does not include zero. This result provides evidence supporting Hypothesis 5.

To examine whether full or partial mediation is present, I specified an alternative model without the direct path between integration mechanisms and absorptive capacity. The model fit slightly decreased ($\chi^2[16] = 21.82$, CFI = 0.96, TLI = 0.92, RMSEA = 0.04) and, because the direct path between integration mechanisms and absorptive capacity in the original model is significant, a partial mediation can be concluded.

Robustness Checks and Post-Hoc Analyses

Several additional analyses were conducted to establish the robustness of the results. First, I specified two additional path models in Mplus to test alternative pathways. In alternative model (a), the relationship between integration mechanisms and absorptive capacity is only mediated by perspective-taking. In alternative model (b), this relationship is only mediated by creative behavior. Table 3.4 compares the indirect effects and fit indices of these alternative models with the hypothesized model. Regarding model fit, both alternative models are relatively worse. Specifically, the TLI value is below the accepted threshold (Hox, 2010). Moreover, the indirect effects are not significant at the 5% level because the 95% CIs include zero. These results rule out alternative pathways and provide additional support for Hypothesis 5.

Second, I performed three multilevel, single-equation regressions in Mplus, including all control variables mentioned above and industry-specific dummy variables, to further examine the robustness of the direct relationships. Since medical technology product segments vary broadly in terms of technological complexity and R&D intensity (de Vet & Scott, 1992), a firm's segment affiliation could partially determine its level of absorptive capacity (Cohen & Levinthal, 1990) as well as its knowledge workers' conditions and behaviors. I therefore considered five medical technology segment dummies in which the sampled firms were predominantly active. The dummies were derived based on business descriptions in publicly available databases and contained: (1) surgical, diagnostic, and therapeutic devices and systems (used as the reference category), (2) medical aids and implants, (3) lab technology and diagnostics, (4) dental products

¹¹ The R-based web-tool for using the Monte Carlo method can be found here: <http://quantpsy.org/>

and instruments, and (5) medical furniture. As reported in Table 3.5, the findings confirm those from the two-level path model regarding Hypotheses 1 through 4, at least at the 5% significance level.

Table 3.4: Summary of Indirect Effects and Model Fit

Two-level path models	Indirect effect		Model fit				
	Estimate	95% CI	χ^2	df	CFI	TLI	RMSEA
Hypothesized model:							
<i>Integration mechanisms</i> → <i>Perspective-taking</i> → <i>Creative behavior</i> → <i>Absorptive capacity</i>	0.16	(0.011; 0.425)	19.00	15	0.97	0.94	0.03
Alternative model (a):							
<i>Integration mechanisms</i> → <i>Perspective-taking</i> → <i>Absorptive capacity</i>	0.15	(-0.010; 0.381)	12.57	8	0.94	0.84	0.05
Alternative model (b):							
<i>Integration mechanisms</i> → <i>Creative behavior</i> → <i>Absorptive capacity</i>	0.18	(-0.012; 0.484)	12.95	8	0.94	0.84	0.05

Note: Estimates and confidence intervals (CI) for the indirect effects based on the unstandardized path coefficients of the respective mediation chain.

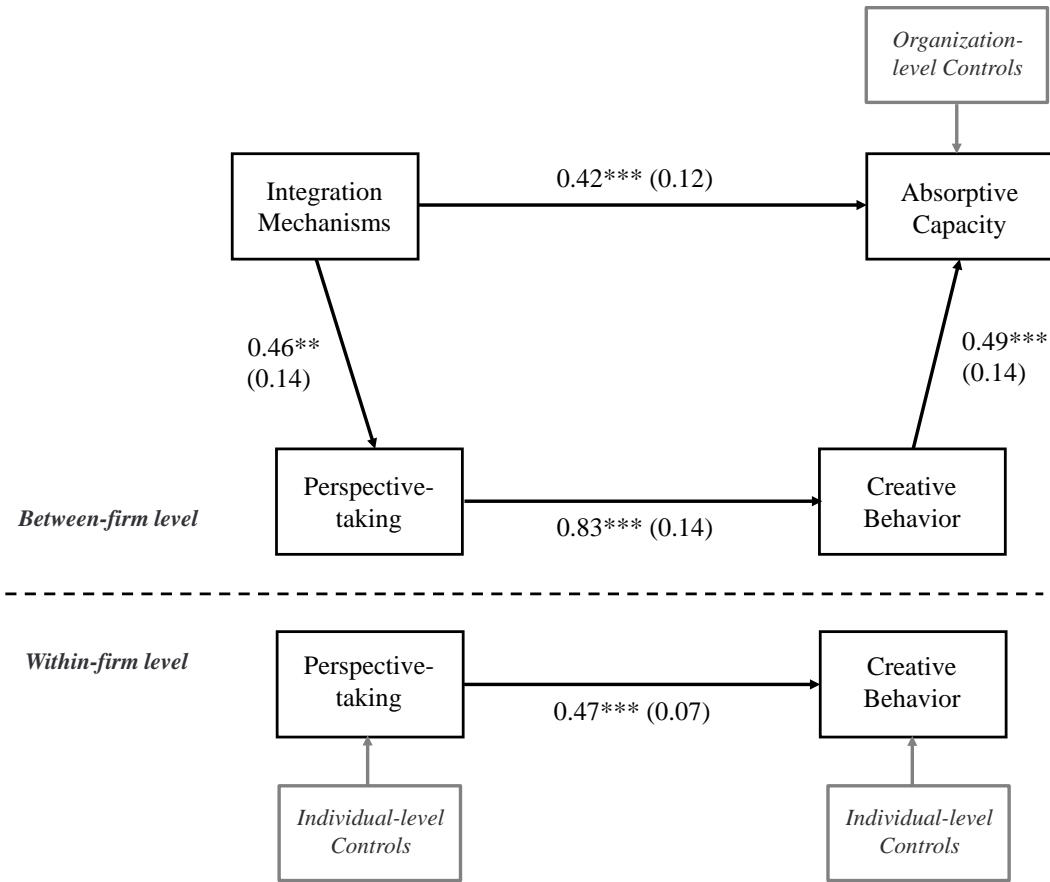
Third, the final sample for the individual level consists of unbalanced groups of two to three knowledge workers per firm. In a simulation, Hox and Maas (2001) found that an imbalance in cluster sizes could affect multilevel SEM performance (see also Preacher et al., 2010). To account for any potential bias caused by unbalanced data, I re-estimated the two-level path model and the three multilevel single-equation regressions with balanced clusters of only two knowledge workers per firm. For the 24 cases with three knowledge workers I selected the two most knowledgeable knowledge workers in terms of function and firm tenure. The findings for balanced clusters presented in Figure 3.3 are consistent with the main analyses. Also, the results of the multilevel, single-equation regressions corresponded to those for the unbalanced data.

Table 3.5: Results of Single Multilevel Regressions

Variables	Model 1: Perspective-taking		Model 2: Creative behavior		Model 3: Absorptive capacity	
	Within-level estimates	Between-level estimates	Within-level estimates	Between-level estimates	Within-level estimates	Between-level estimates
Integration mechanisms		0.37* (0.17)		0.04 (0.17)		0.56*** (0.07)
Creative behavior						0.57*** (0.16)
Perspective-taking			0.49*** (0.07)	0.86*** (0.20)		0.39† (0.20)
Firm size		0.08 (0.17)		-0.09 (0.15)		0.06 (0.08)
Firm age		-0.10 (0.14)		-0.15 (0.16)		0.01 (0.06)
Environmental dynamism		0.33* (0.16)		0.05 (0.14)		0.20** (0.07)
Decentralization		0.13 (0.16)		0.25 (0.15)		0.09 (0.09)
Formalization		-0.06 (0.14)		0.20 (0.14)		-0.16† (0.09)
Medtech segment (2)		0.51** (0.18)		-0.22 (0.15)		-0.00 (0.08)
Medtech segment (3)		0.23 (0.15)		-0.01 (0.14)		0.03 (0.08)
Medtech segment (4)		0.24* (0.11)		0.08 (0.11)		-0.04 (0.08)
Medtech segment (5)		0.15 (0.11)		0.00 (0.12)		0.03 (0.10)
Firm tenure	0.14† (0.08)		0.04 (0.06)			
Marketing function	-0.03 (0.09)		-0.09 (0.07)			
Product management function	-0.12† (0.08)		0.02 (0.07)			
Other function	-0.04 (0.06)		-0.08 (0.06)			

Note: Between-level and within-level estimates reflect the between-level and within-level standardized coefficients, respectively, for the dependent variable at the respective level. Robust standard errors in parentheses. $n = 106$ for organization-level variables, $n = 236$ for individual-level variables. In Model 1, all relationships were specified at the between level only, as absorptive capacity can only vary between firms. In addition, the covariance among perspective-taking and creative behavior was modeled at the within level in this model (not displayed in the table), as they are assumed to be correlated within firms. The missing data estimation technique in Mplus was used to handle missing values regarding firm tenure for $n = 9$ knowledge workers.

† $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Two-tailed tests.

Figure 3.3: Estimated Two-level Path Model for Balanced Cluster Size

Note: Standardized coefficients with robust standard errors in parentheses. $n = 106$ for organization-level variables, $n = 212$ for individual-level variables. $\chi^2[15] = 17.30$, CFI = 0.98, TLI = 0.97, RMSEA = 0.03. Indirect effect: 0.17 ($p < 0.05$), 95% CI (0.022, 0.418). The missing data estimation technique in Mplus was used to handle missing values regarding firm tenure for $n = 5$ knowledge workers.

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$. Two-tailed tests.

Fourth, I computed three ordinary least squares (OLS) regressions by using SPSS for which the individual-level variables were simply aggregated to group means. The aggregation of the individual-level measures is supported because their aforementioned ICCs are above the minimum value of .10 that Bliese (1998) suggested. This more conventional approach does not account for within-firm variance and, thus, does not include the pure within-firm controls. Yet, the results for the direct relationships and the indirect effect are qualitatively consistent with those obtained from multilevel regressions in Mplus (see Table 3.6). To additionally obtain top and senior managers' assessment about their firms' knowledge workers, the questionnaire for the first informants also asked them to rate those employees' perspective-taking and creative behavior. Regarding the 106 firms of the final sample, their ratings for both perspective-taking ($r = 0.32$,

$p < 0.01$) and creative behavior ($r = 0.39$, $p < 0.001$) were strongly correlated to the aggregated ratings obtained from core knowledge workers.¹² Based on the data received from all $n = 148$ first informants, I re-ran the three OLS regressions and found similar results to those from the analyses that included the ratings of core knowledge workers (see Table 3.6).

Fifth, I checked to determine whether empirically distinguishing between the single dimensions of the constructs of absorptive capacity and integration mechanisms – both treated as second-order constructs in the main analyses – yields similar results. With regard to the sub-dimensions of absorptive capacity, I ran several two-level path models and report here, for the sake of simplicity and relevance, only the standardized coefficients of creative behavior with each dimension (referring to Hypothesis 4) and the respective indirect (mediation) effects (referring to Hypothesis 5). Except for the indirect effect on assimilation, the coefficients were all positive and significant, though in some cases only at the 10% level: acquisition (creative behavior [0.50, $p < 0.01$]; indirect effect [0.23, $p < 0.10$; 90% CI: 0.006, 0.573]), assimilation (creative behavior [0.28, $p < 0.10$]; indirect effect [0.14, $p > 0.10$; 90% CI: -0.018, 0.363]), transformation (creative behavior [0.49, $p < 0.01$]; indirect effect [0.17, $p < 0.05$; 95% CI: 0.009, 0.457]), and exploitation (creative behavior [0.38, $p < 0.01$]; indirect effect [0.16, $p < 0.10$; 90% CI: 0.012, 0.373]). Although the direct relationship between creative behavior and assimilation is marginally significant, other variables may be more appropriate to explain the micro-level behavior mediating the macro-level relationship between integration mechanisms and assimilation only.

In addition, I re-ran the models with potential absorptive capacity as a combined measure of acquisition and assimilation and realized absorptive capacity as a combined measure of transformation and exploitation. The obtained results were qualitatively consistent with those obtained when treating absorptive capacity as a second-order construct: potential absorptive capacity (creative behavior [0.45, $p < 0.01$], indirect effect [0.17, $p < 0.10$; 90% CI: 0.016, 0.405]), realized absorptive capacity (creative behavior [0.48, $p < 0.01$], indirect effect [0.16, $p < 0.05$; 95% CI: 0.014, 0.409]).

¹² I also found adequate interrater reliability among first informants and core knowledge workers when calculating the respective ICCs for perspective-taking (ICC = 0.23) and creative behavior (ICC = 0.23) based on all $n = 342$ responses.

Table 3.6: Results of OLS Regressions

Variables	Model 1: Perspective-taking		Model 2: Creative behavior		Model 3: Absorptive capacity	
	Aggregated	First informant only	Aggregated	First informant only	Aggregated	First informant only
Integration mechanisms	0.21*	(0.09)	0.36***	(0.09)	0.01	(0.08)
Creative behavior					0.49***	(0.07)
Perspective-taking					0.25*	(0.10)
Firm size	0.04	(0.07)	0.04	(0.06)	0.10	(0.11)
Firm age	-0.06	(0.10)	-0.04	(0.09)	0.04	(0.05)
Environmental dynamism	0.14†	(0.07)	0.09	(0.07)	0.01	(0.06)
Decentralization	0.06	(0.06)	0.09	(0.06)	0.12*	(0.05)
Formalization	-0.03	(0.06)	0.09	(0.07)	0.05	(0.04)
Medtech segment (2)	0.61**	(0.21)	0.17	(0.18)	-0.11*	(0.05)
Medtech segment (3)	0.29	(0.22)	-0.30	(0.27)	-0.02	(0.15)
Medtech segment (4)	0.49†	(0.25)	-0.39	(0.30)	0.07	(0.19)
Medtech segment (5)	0.41	(0.31)	-0.23	(0.42)	-0.14	(0.26)
Indirect effect					0.12	(0.45)
95 % Confidence interval					0.03*	0.06*
					(0.001, 0.070)	(0.023, 0.102)
R^2	0.20		0.23		0.56	0.65
F	3.46***		4.83***		16.99***	31.44***
n	106		148		106	148

Note: Unstandardized coefficients reported with Huber-White robust standard errors in parentheses.

† $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Two-tailed tests.

With regard to the sub-dimensions of integration mechanisms, when considering only the effects of one dimension (either formal or informal integration) while controlling for the other in the two-level path model, I obtained results that were very similar to those of the main analyses. That is, the indirect effects of formal integration (0.12, $p < 0.05$; 95% CI: 0.003, 0.334) and informal integration (0.12, $p < 0.05$; 95% CI: 0.004, 0.339) on absorptive capacity were both positive and significant. Moreover, I performed multilevel single-equation regressions treating formal and informal integration as separate independent variables to account for the two dimensions' potential distinct effects on absorptive capacity (referring to Hypothesis 1) and perspective-taking (referring to Hypothesis 2).

The respective standardized regression coefficient of formal integration was positive and significant with absorptive capacity (0.37, $p < 0.001$) and perspective-taking (0.30, $p < 0.10$) as the dependent variable, whereas the respective standardized coefficients of informal integration were only positive and significant with absorptive capacity (0.27, $p < 0.01$) but not with perspective-taking (0.12, $p > 0.10$). Compared to the respective standardized regression coefficient of integration mechanisms as a second-order construct with absorptive capacity (0.56, $p < 0.001$) and perspective-taking (0.37, $p < 0.05$) as the dependent variable (see Table 3.5), the size of the single effects of formal integration and informal integration were all smaller and in some cases significant at lower levels or not significant at all. These findings may imply that formal and informal integration complements one another to influence perspective-taking and absorptive capacity.¹³

Finally, the cross-sectional survey design of the study makes the findings potentially vulnerable to endogeneity induced by omitted variables bias, among other causes (Antonakis, Bendahan, Jacquart, & Lalive, 2010). To rule out this issue, including instrumental variables is recommended (Aguinis & Edwards, 2014). Although I did not find viable instruments in the context of the present analysis, I implemented several measures to strengthen the inferences drawn from this study (Antonakis et al., 2010). (1) I included appropriate control variables at both levels of analysis to alleviate worries regarding omitted variable bias. While the consideration of medical technology segments, for example, accounted for a potential segment inherent determination of absorptive capacity between firms, additional individual characteristics such as

¹³ In addition to using the average of the two dimensions of integration mechanisms as a combined measure, I also multiplied these dimensions with one another to further investigate their complementary effect. The standardized coefficient of the multiplicative score with absorptive capacity (0.55, $p < 0.001$) and perspective-taking (0.35, $p < 0.05$) as the dependent variable was similar to that of the averaged score reported here, thus further corroborating the complementarity argument.

firm tenure and functional affiliation of the responding knowledge workers were incorporated to control for their influence within firms. (2) I used robust standard errors throughout all analyses to correct for possible inconsistency in inference (Antonakis et al., 2010). (3) I attempted to reduce potential issues related to common method variance by collecting data from a variety of sources (i.e., top and senior managers, core knowledge workers, and secondary databases). While I was able to minimize the probability of common method bias for relationships across levels (Podsakoff et al., 2003), within levels the chance for bias might be higher, as the main variables were taken from the same informants. However, when I loaded all items from the same data source on a single factor, the resulting models demonstrated a poor fit for both the organization-level and the individual-level source. This provides evidence that common method variance is not a substantial problem when examining the relationships within each level.

3.6 DISCUSSION

The objective of this study was to explore how origins at multiple levels influence absorptive capacity. The empirical data supported my theoretical model (see Figure 3.1) in which I proposed that the positive relationship between integration mechanisms and a firm's absorptive capacity at the organizational level is a simplification for a more fine-grained interplay of the condition and the behavior of individuals. I found that perspective-taking and the resulting creative behavior at the individual level sequentially mediate the organization-level relationship. These findings have noteworthy implications for research into the antecedents of absorptive capacity, the microfoundations of organizational capabilities, and the role of perspective-taking for knowledge integration.

Implications for Absorptive Capacity Research

With regard to the antecedents of absorptive capacity, this study provides new theoretical insights into the concept's multilevel origins. I address three essential gaps concerning the antecedents of absorptive capacity revealed in a literature analysis of the field (Volberda et al., 2010). First, previous studies do not truly explain what and how individual-level factors influence organization-level absorptive capacity. In this study, perspective-taking was an important individual cognitive, situationally motivated foundation because taking the viewpoints of others' within and outside the organization is an important prerequisite for knowledge processing. Influenced by this cognitive process, subsequent creative behavior was identified as another

critical individual antecedent because individuals' efforts to produce new and useful ideas help a firm create value from newly absorbed knowledge. These findings empirically support the original assumptions of prior influential conceptual work suggesting that individuals' cognition and creativity are important elements of absorptive capacity (Cohen & Levinthal, 1990; Lane et al., 2006). Moreover, this study greatly extends this work by enhancing the theoretical understanding of how organizational absorptive capacity is rooted in individual cognition and behavior and how these factors are related.

Second, prior work has neglected the role of formal and informal organizational mechanisms and their relative contributions to absorptive capacity (Volberda et al., 2010). This study addresses this gap and may adjust previous results. For instance, Jansen et al. (2005) found that formal mechanisms such as cross-functional interfaces increase potential absorptive capacity and informal mechanisms such as connectedness enhance realized absorptive capacity. However, I additionally suggest that informal integration is also useful for the acquisition of new knowledge, as it is more flexible, and formal integration also supports the exploitation of knowledge, as it integrates different functional expertise (cf. Todorova & Durisin, 2007). Since I found formal and informal integration to be highly correlated and the combined measurement of integration mechanisms strongly related with absorptive capacity and its four dimensions, it seems that the two types of integration are complements rather than substitutes in influencing absorptive capacity (cf. Gulati & Puranam, 2009). The comparison of the separate effects vs. the combined effect of the two types of integration in the post-hoc analyses corroborates this implication.

Third, the existing literature lacks an explanation for potential interdependencies of organizational and individual antecedents (Lane et al., 2006; Volberda et al., 2010). This study addresses this deficit by conceptually identifying and empirically showing that organizational absorptive capacity emerges from the direct and indirect influence of organizational integration mechanisms on individuals' cognition and behavior. Drawing on a conceptual multilevel framework, this study has shed new theoretical light on the interplay of multilevel origins and on new knowledge absorption and exploitation through the organization. In this regard, my findings suggest that a firm's absorptive capacity is not just the sum of its employees' cognitions and behaviors, but it is also contingent on the organizational mechanisms by which individual contributions are integrated to form a collective outcome (Gupta et al., 2007). Accordingly, these findings highlight the need to conduct more multilevel studies in absorptive capacity research

because an isolated analysis of only one level may lead to erroneous results (Dansereau et al., 1999).

Implications for Microfoundations Research

Concerning the microfoundations of organizational capabilities, the findings indicate that heterogeneity among firms' knowledge workers and their cognition and behavior helps to explain interfirm differences in organizational capabilities. Thus, the study empirically supports the theoretical considerations of influential microfoundations research suggesting that individuals are the fundamental elements of a firm and cannot be assumed to be homogeneous across organizations (Felin & Foss, 2005; Felin & Hesterly, 2007). By studying the characteristics of those employees who are most crucial to new knowledge generation and innovation, I emphasize the critical role that key employees play in the formation of an organizational capability (Gavetti, 2005; Rothaermel & Hess, 2007). My findings imply that firms may not directly act upon the level of firm capabilities to achieve and maintain superior performance (cf. Foss, 2011). Rather, they may form capabilities by recruiting key employees with the required traits or by establishing certain organizational mechanisms that affect the conditions of individuals to promote a certain behavior.

Furthermore, this study addresses the empirical challenges of the microfoundations movement in general (Felin et al., 2015) and reduces the deficits of quantitative empirical research addressing the microfoundations of organizational capabilities in particular (Felin et al., 2012). The study is among the first quantitative analyses that empirically validates Coleman's (1990) bathtub model of macro-micro-macro-level interactions in the context of firm capabilities. To date, methodological constraints on how to accommodate such mediation models in a large N setting – particularly the inability to test bottom-up effects in these models (Croon & van Veldhoven, 2007) – have limited further developments in microfoundational reasoning.

In the present paper, I have used data collected at two levels of analysis, followed the referent shift model in capturing the attributes of a specific group of individuals (Chan, 1998), and applied a recently developed method, multilevel SEM, allowing for upward modeling. In doing so, I provided empirical corroboration to explain relationships between organizational antecedents and capabilities in terms of a sequential mediation of individual conditions and individual actions when theorizing about microfoundations (Abell et al., 2008). Specifically, the empirical data had a better fit with a four-path model according to Coleman's logic than two

alternative three-path models including either only individual condition or only individual action. The empirical approach undertaken in this study meets recent desires to incorporate multilevel design in management research (Aguinis & Edwards, 2014; Bamberger, 2008) and it might be highly valuable for future quantitative studies in further advancing the microfoundations movement.

Implications for Perspective-Taking Research

Regarding the role of perspective-taking for knowledge integration, this study complements prior work (Litchfield & Gentry, 2010), providing new theoretical and empirical insights into how perspective-taking is linked to the different knowledge integration processes related to absorptive capacity and how it can be influenced by organizational determinants. Initially, Litchfield and Gentry (2010) conceptually proposed that individual perspective-taking can be scaled to a firm capability to foster knowledge integration processes related to transformation as one particular dimension of absorptive capacity. Thus, perspective-taking should help in combining apparently incongruous information. I greatly extend and refine this view in two ways. On the one hand, my empirical findings suggest that perspective-taking is not directly related to knowledge integration at the organizational level. I found that perspective-taking needs to be expressed in tangible actions in the form of generating creative ideas before it can contribute to knowledge integration.

On the other hand, I suggest that in addition to transformation, perspective-taking also indirectly affects the other three dimensions of absorptive capacity through creative behavior. Perspective-taking might be important for the acquisition and assimilation of new knowledge because it stimulates individuals' to explore more broadly and give meaning to new associations. Perspective-taking may also be crucial for the exploitation of knowledge because it is directed to attune to the needs of others and, thus, helps in implementing useful ideas. Moreover, this study underscores that integration mechanisms are important determinants of perspective-taking. This finding implies that perspective-taking is motivated cognition and, to some extent, possibly malleable (Boland & Tenkasi, 1995; Litchfield & Gentry, 2010; Parker & Axtell, 2001). However, in contrast to Litchfield and Gentry (2010), my results indicate that perspective-taking is a malleable microfoundation of an organizational capability related to knowledge integration rather than an organizational capability by itself.

Limitations and Future Research

This study has some limitations which at the same time may open avenues for future research. First, the cross-sectional setting of this study does not allow for making strong causal assertions. Although the directions of the proposed relationships in my hypothesized model are theoretically well underpinned, alternative interpretations of the results may also exist. For instance, one could argue that a firm's absorptive capacity affects the creative behavior of its knowledge workers and not vice versa. A firm with a strong capacity to acquire new knowledge from different external sources may provide its knowledge workers with the necessary stimuli to think divergently and to come up with ideas that are explicitly valuable to their external partners (e.g., customers). Therefore, future research can econometrically prove the causal directions of the relationships by adopting longitudinal or experimental designs, and it should attempt to (completely) rule out endogeneity issues by collecting appropriate instrument variables.

Second, the findings of the two-level path model show that perspective-taking and creative behavior only partially mediate the relationship between integration mechanisms and absorptive capacity, as the latter stays significant in the full model. This might indicate that perspective-taking cannot be perfectly managed by organizational determinants but is to some degree a stable disposition that an individual brings into the organization. Moreover, it is possible that the organization-level relationship is additionally mediated by other individual-level variables. For instance, perspective-taking may also affect absorptive capacity through other behaviors not covered in this study. Future work could reveal further micro-level mediators. Third, the findings of this study represent the situation of the German medical technology industry. The generalizability of the results to other populations might be queried. Thus, it would be interesting to undertake a comparable study in another geographic context and in a multi-industry setting to examine whether the associations found in this work can be confirmed.

Finally, the sample for the micro level included only two to three core knowledge workers per firm. Although through applying the referent shift model I attempted to capture the entire group of a firm's knowledge workers and account for differences in respondents' perceptions (Chan, 1998), this approach still represents an approximation for measuring the micro level. The micro-level sample in this study may not be representative and may suffer from selection bias, as the core knowledge workers were selected by the first informant and not randomly drawn from a larger population (Felin et al., 2015). Future studies can adopt a more costly approach. They can endeavor to sample all knowledge workers per firm and employ self-referential measures. Of

course, the identification of these employees from outside the firm is a major challenge and this challenge may further justify the sampling procedure undertaken in this study. However, future studies could, for example, identify star scientists through publication and citation databases (cf. Rothaermel & Hess, 2007) or use register data that could be matched with organization-level observations.

To gain a deeper understanding of how firm-level absorptive capacity emerges from individuals' actions (i.e., bottom-up relationships), future research can further explore how these associations are moderated by organizational factors such as organization design and reward systems. Econometrically, such models can be specified by using the possibilities of multilevel SEM. In a similar vein, further opportunities exist to examine antecedents at the group, business unit, and interorganizational levels and how they interact with one another in influencing absorptive capacity. While I have concentrated on absorptive capacity to study the microfoundations of organizational capabilities, this approach can be adapted to examine the microfoundations of organizational capabilities related to product development, alliances, and acquisitions. Accordingly, future studies can offer further important contributions to the origins of absorptive capacity and organizational capabilities.

Appendix 3: Measurement Scales for Control Variables

The following items were included in questionnaire 1 for the first informants (i.e. top and senior managers). These informants were asked to refer their answers to the whole organization.

Environmental dynamism (adapted from Jansen et al., 2006)

- (1) In our market, changes are taking place continuously.
- (2) Our customers regularly ask for new products and services.
- (3) Changes in our market environment are often intense.

Decentralization (adapted from Jansen et al., 2006)

- (1) There can be little action taken without a supervisor's approval. (reverse-coded)
- (2) A person who wants to make his own decisions will be quickly discouraged.
(reverse-coded)
- (3) Even small matters have to be referred to someone higher up for a final decision.
(reverse-coded)
- (4) Employees almost always need to ask their supervisor before they can do anything.
(reverse-coded)
- (5) Most decisions employees make here have to have their supervisor's approval.
(reverse-coded)

Formalization (adapted from Jansen et al., 2006)

- (1) For every situation in our firm, written procedures are available for dealing with it.
- (2) Rules and procedures occupy a central place in our firm.
- (3) Written job descriptions exist for all positions in our firm.
- (4) Every employee's performance is recorded in writing.

Chapter 4

Resource Cognition as a Managerial Capability: Investigating Performance Implications and Organizational Contingencies¹⁴

Abstract

Recent research has highlighted the concept of managerial resource cognition, which refers to the extent to which managers know and understand corporate resources, as a fruitful element in understanding the micro-processes underlying a firm's strategic resource adaptation. However, a more detailed conceptualization is lacking and it remains unclear under what conditions resource cognition leads to superior firm performance. Drawing on the Penrosian view and the dynamic managerial capabilities perspective, this study further develops resource cognition in terms of top managers' cognitions about the firm's technology- and market-related resources. Using multi-source data for 127 firms operating in a dynamic industry, I investigate how resource cognition affects firm growth. I also explore the contingent role of decentralization and top management team size as important structural elements determining the information flow within a firm and the context in which top managers make strategic decisions. The findings help to advance the concept of resource cognition and have interesting implications for research into dynamic managerial capabilities and the role of organizational design in the microfoundations of competitive advantage.

Keywords: dynamic managerial capabilities, managerial cognition, microfoundations, organizational design.

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4.1 INTRODUCTION

In attempting to better understand why some firms succeed better than others in reconfiguring their resources, research on dynamic capabilities has suggested studying the underlying mechanisms of resource renewal at the top management level because top managers control the orchestration of organizational resources and shape the firm's strategic development (Helfat et al., 2007; Helfat & Peteraf, 2015; Kor & Mesko, 2013; Martin, 2011; Teece, 2007). In this context, a dynamic managerial capability is defined as the "capacity of managers to purposefully create, extend, or modify the resource base of an organization" (Helfat et al., 2007: 24). One specific type of such a managerial capability is managerial cognition,¹⁵ or managers' mental models and interpretive processes which act as the foundation for strategic decision-making (Adner & Helfat, 2003; Eggers & Kaplan, 2009).

Recently, Danneels (2011) further developed managerial cognition in the context of dynamic capabilities by introducing the concept of resource cognition. Resource cognition refers to the extent to which managers can identify the firm's resources and understand their potential for deployment in new tasks (Danneels, 2011). Consistent with the fundamental ideas of Penrose (1959), managers' cognition regarding what their firm can do may help to explain which future paths of resource adaptation a firm follows and how well it retains and improves its competitive position (Danneels, 2011; Eggers & Kaplan, 2013). The importance of such an organizational self-awareness has also been acknowledged by prior related work to, among others, organizational self-knowledge (Rulke, Zaheer, & Anderson, 2000), managerial consensus on firm competences (Marino, 1996), and firm capability monitoring (Schreyögg & Kliesch-Eberl, 2007).

Although the concept of resource cognition seems to be a fruitful element for understanding dynamic managerial capability, to date, this concept has remained conceptual and empirical evidence of its relevance is extremely limited. A more precise conceptualization and operationalization of resource cognition would facilitate further empirical examination (Eggers & Kaplan, 2013). In this regard, the term "resource" appears to be too vague and the concept does not distinguish between different types of resources. Furthermore, we know too little about the performance consequences of resource cognition as a dynamic managerial capability (Sirmon &

¹⁵ In this study, I follow Eggers & Kaplan (2009, 2013) who regard managerial cognition as a dynamic managerial capability *per se* and not as *part of* a broader, organizational dynamic capability which may also involve firm action. Moreover, such a view underscores that "capabilities involve the capacity to perform not only physical but also mental activities" (Helfat & Peteraf, 2015: 831).

Hitt, 2009). In a case study on the failure of the typewriter manufacturer Smith Corona, Danneels (2011) revealed *ex post* that the firm failed to renew itself because its executives lacked an accurate understanding of the corporate resources. However, based on Danneels' study, we can only draw conclusions regarding the negative implications of poor resource cognition; we still lack an understanding of whether and how this managerial capability yields superior firm performance over time.

In particular, the effectiveness of managerial resource cognition might not only be reducible to individual top managers but also might be highly dependent on the organizational conditions top managers face (Eggers & Kaplan, 2013; Helfat & Martin, 2015; Miller, 1987; Wong, Ormiston, & Tetlock, 2011). Helfat and Peteraf (2015), for example, compared the successful renewal of IBM under chief executive officer (CEO) Lou Gerstner to the demise of Kodak and questioned whether Kodak's downfall was only attributable to a lack of superior cognitive capabilities in its top management or whether the organizational context, such as internal structures impeding effective strategic decision-making, would have hindered even the brightest executives. Similarly, Penrose (1959) argued that entrepreneurial resource management may require managers' creative imagination and also be contingent on the organization of the information flow and processing within a firm. Thus, to better understand the performance implications of managerial resource cognition, this study aims to answer the following critical research questions: (1) How does top management's resource cognition influence firm performance? (2) How does organizational design affect this relationship?

Using primary data from a multi-informant survey complemented with secondary data on 127 medical technology firms, the present study offers several contributions to the literature. First, I contribute to the body of literature dealing with organizational self-awareness (e.g., Denrell, Arvidsson, & Zander, 2004; Marino, 1996; Penrose, 1959; Rulke et al., 2000; Schreyögg & Kliesch-Eberl, 2007) by further developing managerial resource cognition as a construct consisting of distinct components. I propose to disaggregate resource cognition into managerial cognition toward technology- and market-related resources as critical assets on which firms rely for strategic change and renewal. In doing so, I detail Danneels' (2011) original concept and suggest an appropriate operationalization that allows for a more fine-grained empirical examination of managerial cognition toward different types of corporate resources.

Second, I advance research into dynamic managerial capabilities (Adner & Helfat, 2003; Helfat et al., 2007; Kor & Mesko, 2013; Martin, 2011). The study highlights *what* specific

cognitive type of dynamic managerial capabilities may impact firm performance (Helfat & Peteraf, 2015) by conceptualizing resource cognition as an intentional, non-routine but patterned cognitive capability contributing to a firm's growth. It also reveals *how* this managerial capability affects performance (Sirmon & Hitt, 2009) by showing that the components of technology and market-related resource cognition have complementary effects on firm growth. Moreover, I examine *when* resource cognition is more effective by exploring the contingent role of decentralization and top management team (TMT) size as important structural elements determining the information flow and decision-making context. Thereby, the paper responds to recent calls to unveil organizational conditions that increase the performance effects of dynamic managerial capabilities (Helfat & Martin, 2015; Helfat & Peteraf, 2015).

Third, this paper addresses the ongoing discussion on microfoundations in strategy and organization research (Felin et al., 2015; Gavetti, 2005). It underscores the importance of a firm's top management as a group of individuals who are highly influential in attaining strategic adaptation through mindful resource management. The study also contributes to the role of organizational design in the microfoundations of competitive advantage (Barney & Felin, 2013; Felin et al., 2012) by theoretically explaining and empirically examining how top managers' cognition interacts with organizational and TMT structure to influence firm growth. In doing so, the paper helps to increase our understanding of how organizational design elements enhance or impede the emergence of firm-level phenomena from the managerial level.

4.2 THEORETICAL BACKGROUND

In her seminal *The Theory of the Growth of the Firm*, Edith Penrose (1959) proposed conceptualizing resources apart from the services they can render. A resource is "fungible" meaning that the same resource can be applied in different ways or for different tasks and in combination with other resources to offer a range of different services (Penrose, 1959: 25). This potential variety of applications of a firm's resources constitutes the firm's productive opportunity set, that is, the set of potential products for which the resources can be used and the potential markets the resources can address (cf. Foss & Foss, 2005, 2008; Gruber, MacMillan, & Thompson, 2012). Identifying this opportunity set depends on the firm's managers and their subjective perceptions of the causality between the resources and the services of the resources (Gruber et al., 2012; Kor & Mahoney, 2004; Kor, Mahoney, & Michael, 2007; Penrose, 1959).

Similar to Penrose's argument, Danneels (2011: 21) developed the concept of *resource cognition* by defining resource cognition as "the identification of resources and the understanding of their fungibility." Resource cognition leads to so-called resource schemas that represent managers' mental models of the firm's resources and reflect the extent to which managers know what the firm's resources are and understand how they can be applied for new uses or to render alternative services (Danneels, 2011). Resource cognition requires managers to abstract a resource from a particular task or product in which the resource is currently employed and to see the resource in its own right (cf. Danneels, 2002, 2007). Managers' understanding of the firm's resources is a critical antecedent to strategic decision-making and enables the firm to adapt its resource base to shifting environments (cf. Adner & Helfat, 2003). Thus, resource cognition is a fruitful element in the dynamic capabilities view. Specifically, resource cognition may enable us to better understand the micro-level mechanisms that determine firms' pathways of strategic renewal (Danneels, 2011; Helfat et al., 2007).

The importance of firms knowing their own resources and competences has been underscored in prior related work (see also Denrell et al., 2004; Eggers & Kaplan, 2013). Rulke et al. (2000) introduced the concept of organizational self-knowledge, pointing to the need for unit managers to understand the current capabilities of their own unit to better identify and acquire new knowledge from which their unit can really profit. Also, Foss and Foss (2008) proposed entrepreneurs having knowledge about the different attributes of firm resources, which is accumulated through resource learning, is conducive to opportunity discovery. Schreyögg and Kliesch-Eberl (2007) suggested establishing capability monitoring within a firm to permanently observe and reflect on resources and capabilities and to detect early on any potential maladjustments to changing requirements of the environment. Similarly, Garg et al. (2003) studied CEOs' scanning emphases and revealed that scanning the firm's internal environment in addition to its external environment is necessary to foster CEOs' understanding of firm resources, which in turn facilitates their match with external opportunities. Marino (1996) suggested that managers should build agreement and consensus about the core competences of the firm as a prerequisite for subsequent decisions about how to leverage these competences (e.g., for new markets). Teece (2007) further argued that the use and recombination of resources requires detailed knowledge about the structure of the resource base.

These prior articles share several basic aspects with Danneels' (2011) work by emphasizing the idea of organizational self-awareness. However, the concept of resource cognition extends

this work and offers a more fine-grained understanding by decomposing resource cognition into two crucial dimensions: (a) identification of the firm's resources and (b) understanding the fungibility of the firm's resources. Moreover, in contrast to prior work, the concept of resource cognition is more explicit regarding where to locate resource cognition within the firm. It is placed at the top management level because the responsibility for resource orchestration and the locus of attention to strategic issues is usually concentrated at this level (Castanias & Helfat, 1991). While the acquisition and processing of information about the opportunities of firm resources may also appear at other corporate levels, it is at the level of the top management that this information is consolidated and evaluated for strategic decision-making (Cho & Hambrick, 2006; Daft & Weick, 1984). In this regard, resource cognition can be understood as a managerial capability reflecting the capacity of top managers to perform mental activities (Helfat & Peteraf, 2015) and it can be distinguished from Schreyögg and Kliesch-Eberl's (2007) idea of capability monitoring, which the authors described as a separate organizational function regardless of specific individuals.

More specifically, I suggest that managerial resource cognition can best be conceptualized as a *dynamic managerial capability* (Adner & Helfat, 2003; Eggers & Kaplan, 2013; Helfat et al., 2007) akin to the notion of entrepreneurial resource management because it emphasizes the entrepreneurial role of top managers under conditions of change (Foss, Klein, Kor, & Mahoney, 2008; Kor, 2003; Teece, 2007, 2012, 2014). In strengthening this conceptualization, I argue that resource cognition fits the general attributes that characterize a dynamic managerial capability as postulated in recent research (Beck & Wiersema, 2013; Helfat & Martin, 2015; Helfat & Winter, 2011; Martin, 2011). First, a dynamic managerial capability usually must have an intended purpose with an objective (Augier & Teece, 2009). Resource cognition fulfills this criterion well as it represents a managerial cognitive activity intended to adapt the resource base; it forms the foundation for reconfiguring existing resources such that they render new services or, in Penrose's words, explore and exploit the productive opportunity set of the firm (Foss et al., 2008; Gruber et al., 2012; Penrose, 1959).

Second, a dynamic managerial capability should involve patterned, reliable, and repeatable elements (Beck & Wiersema, 2013; Helfat & Martin, 2015; Martin, 2011). With its two distinguishable dimensions of identification and understanding of fungibility, resource cognition exhibits a certain pattern. Although resource cognition contains executives' subjective and creative imagination of alternative uses of resources and, thus, allows for some degree of

spontaneity, it does not equate to ad-hoc problem-solving – an aspect that is well in line with Beck and Wiersema's (2013) definition of dynamic managerial capability. Rather, resource cognition draws on the cognitive skills of top managers that they can deploy on a repeatable and reliable basis. Finally, a dynamic managerial capability should lead to an outcome that is noticeable as such (Helfat & Martin, 2015; Helfat & Winter, 2011). Regarding resource cognition, potential outcomes are recombined resources, new applications for existing resources, the realization of new products or services based on transformed resources, and eventually a recognizable strategic change (e.g., expansion into a new product market).

The mere possession of a dynamic managerial capability does not ensure superior firm performance (Beck & Wiersema, 2013). Rather, superiority is a question of how effectively a capability is performed (Eisenhardt & Martin, 2000; Helfat & Martin, 2015). To measure the effectiveness of a capability, Helfat et al. (2007: 7) proposed using the conception of “evolutionary fitness,” which refers to how well a capability permits a firm to survive and succeed over time (see also Wilden et al., 2013). This approach points to the need to disentangle a capability from its performance and to clearly outline this relationship to avoid any tautology of equating dynamic capabilities with firm performance (Helfat & Martin, 2015).

In a similar vein, it is important to assess the performance of managerial resource cognition. However, in Danneels' (2011) original article, a study on the failure of the typewriter manufacturer Smith Corona, this issue was not explicitly addressed. While the study described ex post how a poor understanding of a particular firm's resource may lead to the firm's demise, we lack knowledge about whether and how managerial resource cognition may yield superior firm performance. Thus, the present paper addresses this shortcoming by examining the relationship between managerial resource cognition and *firm growth*. As Helfat et al. (2007: 15) suggested, firm growth is an appropriate metric to measure the extent of evolutionary fitness because it involves “a time dimension that explicitly incorporates the dynamic aspect of evolutionary fitness.” Moreover, following the entrepreneurship literature (Covin, Green, & Slevin, 2006; Kor, 2003), firm growth reflects a firm's success in pursuing entrepreneurial opportunities, making it suitable to assess the effectiveness of resource cognition that is directed to exploit the firm's productive opportunity set.

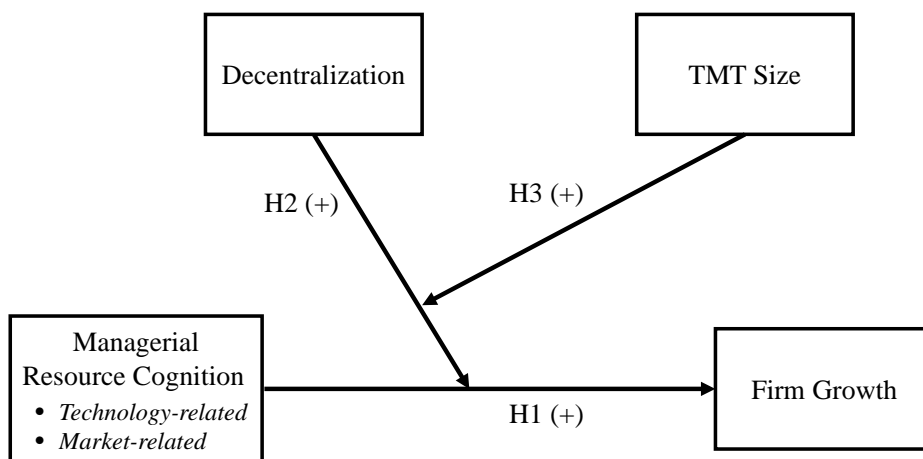
To further explore the effectiveness of a dynamic managerial capability, recent research has called for investigating the conditions under which a dynamic managerial capability leads to superior firm performance (Helfat & Martin, 2015; Helfat & Peteraf, 2015). While some

organizational contexts might enhance the effects of managerial capabilities, other firm-internal structures may set limits that can hinder even the brightest top managers (Helfat & Peteraf, 2015). In responding to these calls, this paper also examines the impact of managerial resource cognition on firm growth by studying how two important organizational design elements, decentralization of decision-making (Hage & Aiken, 1967) and TMT size (Sanders & Carpenter, 1998), influence this relationship.

4.3 THEORETICAL MODEL AND HYPOTHESES

In this section, I build a couple of hypotheses pertaining to the main effect of resource cognition on firm growth and the different interactional effects of resource cognition, decentralization, and TMT size on firm growth. Figure 4.1 shows the theoretical model of this study and provides an overview of the key variables and hypotheses.

Figure 4.1: Theoretical Model



Two Components of Resource Cognition and Firm Growth

To date, the conceptualization of resource cognition is still of a more abstract nature, which makes it difficult to investigate its performance implications. In particular, the term resource is used in a rather vague manner without addressing more specific kinds of resources. Thus, to make the concept more concrete, to facilitate its operationalization, and to better empirically and theoretically address the impact of resource cognition on firm growth, I further distinguish between two fundamental resource types found in organizations (Mitchell, 1992; Song et al., 2005). I propose to disaggregate resource cognition into the two components of *technology-related resource cognition* and *market-related resource cognition* based on previous capabilities-based research which performs a similar disaggregation (e.g., Danneels, 2008; Talke et al., 2011).¹⁶

Specifically, I selected these two types of resources because they represent important vehicles for firms to induce strategic change and firm renewal. Technology-related and market-related resources are considered specialized, hard-to-replicate assets on which firms rely when expanding into new product markets (Mitchell, 1992) and the literature has frequently highlighted them as the two main resource types required to perform the tasks necessary for product innovation (Danneels, 2002; Kor & Mahoney, 2005; Moorman & Slotegraaf, 1999; Song & Parry, 1997). In the following, I further define the two components of resource cognition. I hypothesize that cognitions toward both types of resources contribute to superior firm growth because they ease the recognition of new opportunities for these resources and improve the decision-making and decision implementation regarding the transformation of these resources.

Technology-related resource cognition. Technology-related resource cognition refers to the extent to which top managers identify and understand the fungibility of those resources that enable the development and production of certain products (Mitchell, 1992; Song et al., 2005). These resources contain technological competences such as technological knowledge and manufacturing know-how, but also other technical resources such as product design equipment and plants (Benner & Tushman, 2002; Danneels, 2002, 2007). To identify the firm's technologies in their own right, top managers must make a cognitive effort to mentally disentangle the technologies from the particular products in which they are currently used (Hamel & Prahalad,

¹⁶ Such distinctions have been made in terms of technology orientation versus market orientation as distinct aspects of a firm's strategic orientation or research and development (R&D) competence versus marketing competence as two types of second-order competences.

1994). However, the identification of these resources might be a complex cognitive inquiry because technologies have a high degree of tacitness (Grant, 1996; Teece, 1982) and are very much intertwined with products (Danneels, 2007). To understand the fungibility of a technological resource, top managers must extensively search for information about different possible applications (Gruber, MacMillan, & Thompson, 2008). The recognition of new applications may require executives to characterize a technology in terms of its knowledge components and to recombine these with components of other technologies (Fleming & Sorenson, 2004; Galunic & Rodan, 1998; Gruber et al., 2008).

Even though this cognitive inquiry can be complex, it may enable top managers to reveal the unexploited potential of existing technologies and to shape opportunities for further expansion and growth (cf. Penrose, 1959; Teece, 2007). After finding an alternative application for the technology, the top management decides whether it will invest in R&D (e.g., adjustments in plants or equipment) to transform the technology into a new product. Such investment decisions may be extremely critical since R&D investments are to some degree risky and may not pay off (García-Manjón & Romero-Merino, 2012). Moreover, when entering a new product market, the firm may make errors in applying the technology properly due to a still insufficient comprehension of the technical requirements of the new product and a lack of experience in the new market (Mitchell, 1992). However, if the investment decision is grounded in a thorough cognition of the technological resource in question, the firm is more likely to avoid or quickly recover from early mistakes and is better able to benefit from a greater understanding of the new product's technical requirements, thereby increasing the chances that the initial R&D investments yield successful new products (García-Manjón & Romero-Merino, 2012; Mitchell, 1992).

Market-related resource cognition. Market-related resource cognition refers to the extent to which top managers identify and understand the fungibility of those resources that enable relations with certain customers (Mitchell, 1992; Song et al., 2005). These resources include customer understandings such as knowledge about customers' needs and preferences, but also other marketing resources such as distribution and communication channels and brands (Danneels, 2002, 2003; Day, 1994). Top managers' cognition regarding these resources may provide the basis for future growth within the firm's current market domains and expansion into new markets. Executives in general make better and quicker decisions when they have accurate real-time information about the firm's resources and environmental conditions (Eisenhardt, 1989; Garg et al., 2003). This holds especially true for decision-making about the transformation of

marketing resources because customers' preferences can quickly change (Teece, 2007). With regard to current market domains, for example, owing to a profound customer understanding that requires seeing customers' needs apart from a particular product, top managers more easily recognize upcoming opportunities to better serve the firm's current customers (Danneels, 2003, 2011). On this basis, top managers' decisions about the allocation of means to support appropriate initiatives will likely be sound and the firm will eventually be better able to offer its customers new products that are superior to those of competitors (Narver & Slater, 1990).

With regard to the expansion into new product markets, based on imagining alternative uses of core marketing competences, executives can explore the attractiveness of alternative customers and envision new market domains that do not yet exist (Danneels, 2003; Hamel & Prahalad, 1991). This necessitates that top management mentally decouple a certain marketing resource from its current market setting and then connect it to an alternative or new product market in which the competence has value (Danneels, 2002). An example of such a transfer of market-related resources is brand extension (cf. Danneels, 2011). To achieve further growth, a firm leverages an established brand name to another, often novel product category (Tauber, 1988). The success of this extension depends on executives' awareness of the brand's fungibility, that is, their thorough knowledge of the beliefs customers associate with the brand and whether these beliefs will be attributable to the new product category (Aaker & Keller, 1990).

Complementarity of technology and market-related resource cognition. As prior research has pointed out (Mitchell, 1992; Moorman & Slotegraaf, 1999; Shane, 2000; Song et al., 2005), technology-related and market-related resources have only limited value when deployed in isolation from each other, whereas their connection provides the highest benefits. For instance, the development of a new product necessitates linking technologies and customers (Danneels, 2002). Following this logic, the cognitions regarding the two types of resources can be regarded as complementary. When top managers have identified an alternative application for a certain technology, they must know whether and how existing market-related resources can be used or adapted to commercialize that application. Similarly, when top managers know, for example, how the firm's customer understanding can be used to provide customers with a new product that better meets their preferences, they should also understand how existing technologies might be used to produce the new product. Taken together, a high degree of technology- and market-related resource cognition will help top management decide whether it is worthwhile and feasible for the firm to develop a new product or expand into a new market based on existing resources or

whether new resources must be acquired (cf. Capron & Mitchell, 2009). I therefore assume that the combination of both components of resource cognition may provide the firm with opportunities to grow. Hence, I postulate:

Hypothesis 1: The higher managerial resource cognition (as a combination of technology- and market-related resource cognition), the higher firm growth.

The Role of Organizational Context

As Penrose (1959: 41) argued, entrepreneurial resource management may not solely require the creative imagination of top managers, but is also “closely related to the organization of information-gathering and consulting facilities within a firm.” In a similar vein, the extant research in the upper echelons and leadership literature has emphasized organizational structure (e.g., Salaman & Storey, 2002; Shamir & Howell, 1999; Wong et al., 2011) and TMT structure (e.g., Alexiev, Jansen, Van den Bosch, & Volberda, 2010; Cao, Simsek, & Zhang, 2010; Ling & Kellermanns, 2010) as organizational contingencies influencing the effectiveness of executives’ activities, as they determine the structure of information flow within a firm and constitute the context in which top managers make decisions (Certo, Lester, Dalton, & Dalton, 2006; Mihalache, Jansen, Van den Bosch, & Volberda, 2014).

I focus on decentralization of decision-making and TMT size as two important structural elements. Decentralization was chosen because it reflects the distribution of decision-making authority within a firm (Miller, 1987) and directly affects how top managers perceive information (Sutcliffe, 1994). Although other, similar organizational variables, such as formalization and complexity, are also relevant to information flow, they have only an indirect influence through their bearing on the structure of communication (Sutcliffe, 1994). TMT size was selected because it reflects the top management’s structural and compositional context in a parsimonious way (Amason & Sapienza, 1997). In particular, TMT size is a critical determinant of top management’s capacity to process information (Haleblian & Finkelstein, 1993; Sanders & Carpenter, 1998) and it can have an effect on the dynamics of strategic decision-making (Alexiev et al., 2010; Simsek, Veiga, Lubatkin, & Dino, 2005). In the following, I hypothesize that, through their influence on information-processing and decision-making, decentralization and TMT size affect the extent to which managerial resource cognition fosters firm growth.

The role of decentralization. Decentralization refers to the extent to which authority and decision-making are distributed in an organization (Hage & Aiken, 1967; Jansen et al., 2006). The higher the degree of decentralization, the higher is the degree of decision-making authority that is delegated from the top to the middle and lower levels of the organization (Wally & Baum, 1994). Decentralization can be regarded as a continuum from the low-end anchor ‘centralized’ (i.e., low level of decentralization) to the high-end anchor ‘highly decentralized’ (Wong et al., 2011) and provides an important means for organizing information flows within a firm (Dobrajska, Billinger, & Karim, 2015; Miller, 1987; Tushman & Nadler, 1978).

In this regard, the extant research has revealed advantages and detriments of choosing between a more centralized and a more decentralized organizational structure (Olson, Slater, & Hult, 2005; Wong et al., 2011). Decentralized organizations have advantages over centralized organizations, particularly in terms of higher employee motivation and more effective information flow, because information is less likely to decay or become distorted as it does not pass through several hierarchical levels (Aghion & Tirole, 1997; Sutcliffe, 1994; Wong et al., 2011). In contrast, centralized organizations are associated with clearer responsibilities and communication lines, more efficient information-processing and decision-making, and fewer conflicts than decentralized organizations (Baum & Wally, 2003; Galbraith, 1977; Miller, 1987; Olson et al., 2005; Wally & Baum, 1994).

Regarding the effectiveness of managerial resource cognition, I consider decentralization to be enhancing and centralization to be impeding. To decide which strategic opportunities to pursue or, more precisely, which new application of a technology or alternative use of a market-related resource should be implemented, top managers heavily rely on information from lower-level employees who work daily with the firm’s technologies and interact with customers (Salvato, 2009). However, technological and market information usually involves highly specialized knowledge, which makes it difficult and time-consuming to transmit between individuals (Jensen & Meckling, 1992; Kogut & Zander, 1992). In a centralized organization, the transfer of this information to the top of the organization is even more difficult than in a decentralized organization (Sutcliffe, 1994). Lower-level information might be biased once it arrives at the top management because the information travels through various levels and may be miscommunicated or differently accentuated at each level (Wong et al., 2011). Accordingly, top managers cannot count on lower-level expertise to make sound decisions (Mihalache et al., 2014)

and they risk becoming isolated from current technological and market developments (Teece, 2007).¹⁷

In decentralized organizations, in contrast, employees at lower levels are more involved in the actual decision-making process and, thus, are more engaged in acquiring and transferring information from the environment that is relevant for top-level decisions (Baum & Wally, 2003; Sutcliffe, 1994). In this way “decentralization [...] brings top management closer to new technologies, the customer, and the market” (Teece, 2007: 1335). Moreover, while managerial resource cognition enables a firm to recognize new opportunities for alternative uses of resources, decentralization aids the firm in actually realizing these opportunities (Foss et al., 2013; Foss, Lyngsie, & Zahra, 2015) and materializing them into further growth of the firm. For instance, once a new product application for an existing technology has been introduced, as mentioned above, a firm may face initial technical problems and market uncertainties when actually using the technology in the new area (Mitchell, 1992). In a decentralized organization, where more authority is delegated to lower level engineers and sales personnel, these employees are more motivated to collect additional information, generate valuable ideas to fix technical problems, and make appropriate adjustments to market the product (Jansen et al., 2006; Sheremata, 2000).

Taken together, although in centralized structures decision-making and implementation tend to be more straightforward (Olson et al., 2005; Wally & Baum, 1994), in the long run, when considering the impact of resource cognition on firm growth, the benefits of decentralization will likely prevail. Due to the higher quality and quantity of information available, top managers may make better informed decisions for the alternative use of resources and, due to higher employee empowerment, the realization of those decisions is likely to be more effective. Thus, I suggest the following:

Hypothesis 2: Decentralization positively moderates the relationship between managerial resource cognition (as a combination of technology- and market-related resource cognition) and firm growth.

¹⁷ As pointed out by prior conceptual research (e.g., Sheremata, 2000; Teece, 2007) and adopted by recent empirical work (e.g., Mihalache et al. 2014; Wong et al., 2011), centralization is usually accompanied by hierarchy – a view which is also adopted in this study. However, it should also be acknowledged that a centralized organization may not necessarily mean an organization with many hierarchical layers. There might be organizations that are very centralized but also very flat.

The role of TMT size. TMT size refers to the number of top management's team members (Sanders & Carpenter, 1998). Consistent with frequently used definitions in the upper echelons literature (Carpenter, Geletkanycz, & Sanders, 2004), a firm's TMT usually reflects the top two tiers of a firm's management (Carpenter, 2002; Wiersema & Bantel, 1992) and encompasses those managers who directly participate in strategic decision-making (Amason & Sapienza, 1997; Collins & Clark, 2003), directly report to the CEO (Boeker, 1997; Guadalupe, Li, & Wulf, 2014), and usually hold an organizational title of vice president or above (Sanders & Carpenter, 1998). TMT is often regarded as a firm's center of information-processing (Haleblian & Finkelstein, 1993; Thompson, 1967). As indicated in the extant research (cf. Certo et al., 2006), both larger TMTs and smaller TMTs have benefits. With greater cognitive resources, larger TMTs have higher abilities to process information and solve critical problems than smaller TMTs (Amason & Sapienza, 1997; Haleblian & Finkelstein, 1993; Hoffman, Lheureux, & Lamont, 1997). On the other hand, smaller TMTs usually reach a consensus faster than larger TMTs because they are more cohesive, have higher communication frequency, and coordination among team members tends to be easier (Simsek et al., 2005; Smith et al., 1994; Wiersema & Bantel, 1992).

With regard to the relationship between managerial resource cognition and firm growth, I propose that increasing TMT size may amplify the contingent effect of decentralization postulated in Hypothesis 2. The increase in the quantity of information that decentralization entails (Sheremata, 2000) puts higher information-processing demands upon top managers (Henderson & Fredrickson, 1996). Larger TMTs, as they consist of more team members, may be better able to gather and handle a high number of items of information (Certo et al., 2006; Haleblian & Finkelstein, 1993; Hoffman et al., 1997). Thus, an increase in TMT size may extend the scope of 'receptors' at the top of the organization vis-à-vis the firm's decentralized information sources (Wulf, 2012) and may enhance the convergence of the distributed information to be interpreted for strategic decisions (Daft & Weick, 1984). In particular, as technological and market environments can quickly change (Jaworski & Kohli, 1993), a larger TMT might be better equipped to cope with the fast-moving nature of technological and market information (Daft, Sormunen, & Parks, 1988; Haleblian & Finkelstein, 1993).

In addition to its higher information-processing abilities, a larger TMT is also associated with a greater problem-solving capacity. With more members on a team, a wider range of views can be considered when analyzing problems, more critical opinions and specialized skills may be employed to correct errors during decision-making, and a higher number of promising solutions

to problems might be produced (Amason & Sapienza, 1997; Certo et al., 2006; Halebian & Finkelstein, 1993). Thus, a larger TMT may further improve the quality of decisions regarding how to pursue alternative uses of the firm's existing resources. Furthermore, while decentralization brings top management closer to the front line, a larger TMT more strongly takes advantage of this structural condition by further augmenting top management's involvement in the actual implementation of decisions. With more team members, top management might have a greater capacity to monitor the realization of an alternative use for a given resource and intervene more readily when problems occur, for example, by providing additional means for a new product project to finally succeed (Felekoglu & Moultrie, 2014). Although large TMTs may also have more difficulties in reaching consensus and be less cohesive (Smith et al., 1994), their advantages can outweigh their detriments by further enhancing the positive effects of decentralization. Hence, I propose:

Hypothesis 3: A three-way interaction exists among managerial resource cognition (as a combination of technology- and market-related resource cognition), decentralization, and TMT size: The relationship between resource cognition and firm growth is strongest when the degree of decentralization is high and TMT size is large.

4.4 METHODS

Sample and Data Collection

To test the hypotheses of this study, I gathered primary data through a survey instrument, which was complemented by additionally collected secondary data. In following prior upper echelons research that proposed the use of primary data for an accurate measurement of managerial skills and actions (e.g., Goll & Rasheed, 2005; Li, 2013), the survey instrument allowed me to more directly capture the extent of a firm's top management resource cognition than when using proxies based on purely secondary data. Although surveys in general are prone to some degree of measurement error (Billiet & Matuso, 2012), this design is helpful in further empirically exploring a concept that has been introduced on the basis of a single case study and is still in an early stage (cf. Danneels, 2011), across a larger number of observations.

I chose firms operating in the German medical technology industry as the empirical setting for this research for two main reasons. First, to properly assess the performance of dynamic

managerial capabilities, Helfat and Martin (2015) suggested measuring the impact of a dynamic managerial capability on firm performance either as an indirect effect mediated by a specific form of strategic change (e.g., acquisitions) or as a direct effect under conditions of change (e.g., an industry context undergoing constant change). In following the latter approach, the medical technology industry is suitable because it is characterized by short product lifecycles (i.e., only about 18 to 24 months until an improved product is introduced), a high rate of new inventions (as indicated by the highest number of patent applications among all industry sectors), and a large number of different and constantly changing technologies (Eucomed, 2014). Second, the medical technology industry is highly heterogeneous in terms of product segments and sub-segments (Eucomed, 2014). At the same time, great potential of interrelatedness exists between the different (sub-)segments as they often pursue the same (ultimate) purpose, such as diagnosis of disease or support through therapeutic measures. In this regard, many firms in this industry sector have undergone several resource and business reconfigurations over time (Karim, 2009; Karim & Mitchell, 2000), making this research setting highly relevant for studying managerial cognition regarding alternative uses of resources.

To attain a representative sample of the most important firms in this sector, I compiled an initial list of the 600 largest medical technology firms in Germany based on sales revenues. This list was generated from the Creditreform database, which provides a comprehensive listing of German companies, by constraining the search scope to the industry classification codes for medical technology in Germany (WZ 266 and/or 325). However, several firms on the initial list were not suitable for the purpose of this study because they represented pure trade companies without any R&D or manufacturing function or were erroneously classified as a medical technology firm but in fact were active in another field. The exclusion of these firms yielded a base sample of 394 firms. Through the support of two major medical technology associations and trade fairs whose members largely overlapped with the base sampling it was aimed to promote the study and to boost the response rate. In doing so, 13 additional firms were considered that fit the criteria of the target population but were not found in the initial sampling approach. In total, 407 firms were identified as relevant and represented the sampling frame of this study.

To limit potential issues related to common method bias, I collected data from multiple sources. Specifically, I used different sources for the independent and dependent variables (Podsakoff et al., 2003). Regarding the independent variables, I relied on a member of the executive board (e.g., the CEO) or another top/senior manager as first informant because these

individuals possess detailed knowledge about the firm's organizational structures and, by definition, top management's resource cognition (cf. Sutcliffe, 1994; Wally & Baum, 1994). To improve the accuracy of the data, information on TMT structure was gathered from secondary data sources (as described in more detail in the measurement section below). Regarding the dependent (performance) variable, I relied on up to three key employees per firm as second informants who hold jobs crucial for knowledge creation and innovation, such as project managers in R&D and marketing. These so-called core knowledge workers have been identified in prior research as highly knowledgeable and important for the growth of companies in dynamic and knowledge-intensive industries (Collins & Smith, 2006; Smith et al., 2005). Furthermore, I used company databases of the Bureau van Dijk and Hoppenstedt as well as other publicly available sources for secondary data on firm size, firm age, and industry characteristics.

In a first step, I approached the potential first informants via phone and provided them with general information about the study. Those who gave their consent to participate were asked to provide the contact details of up to three key knowledge employees. In a second step, I emailed both first and second informants personal invitations ensuring confidentiality and including the respective questionnaire together with a link to the online version of the survey. If the potential informants did not respond, I sent reminder emails and postal letters and conducted follow-up phone calls. From the 407 relevant firms, 152 provided responses, reflecting a response rate of 37 percent (participating firms). In total, 148 and 267 questionnaires were received from the first and second informants, respectively, yielding a potential sample of 128 firms with responses from both informants (with at least one second informant). However, due to missing values, the responses from 1 first informant and 23 second informants were excluded. Moreover, four responses that were received beyond the requested maximum number of three second informants per firm were not considered for lack of informant qualification and consistency reasons. Thus, the final sample contained 127 firms with matched first and second informants. Specifically, the distribution of second informants ($n = 240$) among those firms was as follows: 34 firms with one, 73 with two, and 20 with three second informants.

The respondents exhibited a high degree of knowledgeability. While the first informants were predominantly top/senior managers and had, on average, 12.4 years of firm experience, the second informants had mainly an R&D or marketing function with an average firm tenure of 9.2 years. With regard to general statistics about the firms in the final sample, the median age of the firms amounted to 35 years since founding (mean = 55.7, S.D. = 46.81), their median size was

200 employees (mean = 1795.1, S.D. = 8845.45), and their TMT size was, on average, 5.6 (median = 6.0, S.D. = 2.83); 42 percent of the firms had more than 250 employees, 51 percent ranged between 50 and 250 employees, and only 7 percent can be considered small (having less than 50 employees). Thus, most of the firms were large enough to be assumed to have well-developed formal organizational structures. Moreover, I checked the data for non-response bias. I compared responding and nonresponding firms regarding two general characteristics: revenues and total number of employees based on information provided by the Creditreform database. I also compared early and late respondents and tested whether they differed in terms of the central variables of this study. No significant differences ($p > 0.10$) were found for these comparisons, indicating that the sample was not affected by non- or late-response bias.

Measurement and Validation of Constructs

Apart from TMT and firm and industry characteristics, I used perceptual measures for this study and tried to rely on existing scales by adapting them to the research setting. However, a scale for resource cognition was not available and had to be developed for this study. The validity of the constructs was verified based on several analyses. Unless otherwise indicated, all scale items were based on a seven-point Likert scale with 1 for “strongly disagree” to 7 for “strongly agree” as anchor points. The newly developed scale for resource cognition and the scales used to measure decentralization and firm growth are described below. All other scales used as control variables are shown in the appendix of this chapter.

Development of a scale for managerial resource cognition. I developed the scale for managerial resource cognition according to the best practices recommended in the literature (Churchill, 1979; Hinkin, 1998; Worthington & Whittaker, 2006) and by following a three-step process of generation of scale items, scale refinement, and scale validation (see also Scholz, 2012, who performed a similar approach). In the first step, an initial list of items was generated in a deductive manner, meaning that the items were based on existing theoretical foundations, thereby helping to establish content validity (Hinkin, 1998). Therefore, Danneels’ (2011) original definition of resource cognition reflecting the two dimensions of resource identification and understanding of resource fungibility formed the basis for operationalization of the concept. The basic understanding was also informed by related conceptual work regarding the importance of knowing one’s own resources (Marino, 1996; Schreyögg & Kliesch-Eberl, 2007) and their potential applications (Penrose, 1959). Furthermore, a thorough analysis of the capabilities-

related innovation literature revealed technology- and market-related resources as the two key resource types needed to perform innovation tasks and expand into new markets and, thus, corroborated the proposed disaggregation of resource cognition into the two components of technology-related and market-related resource cognition.

Through exploratory interviews, these theoretical considerations were discussed with CEOs and other top managers. The interviewees confirmed the importance of resource cognition and the need to specify the type of resources. As several interviewees stated, the term resource can mean different things to different managers. For instance, while some managers would spontaneously think of financial resources, others would have human resources in mind when they are asked about the firm's resources. The interviewees also affirmed the insight from the literature to concentrate on technology- and market-related resources as critical assets on which firms rely for innovation and strategic change. Moreover, some supported the assumed complementarity of both components of resource cognition. One interviewee, for example, said that his top management team often identifies alternative applications for the firm's technologies but then abandons further developments because the team lacks a thorough understanding of how to adapt the marketing resources to market the application.

Based on these interviews and on related empirical efforts to measure organizational self-knowledge (Rulke et al., 2000) and capability evaluations (Denrell et al., 2004), I generated two subscales that reflect the two components of resource cognition, each mirroring the identification and understanding of fungibility of the respective resource type. Regarding *technology-related resource cognition*, eight items were developed on the basis of prior literature on the use of technological resources (Danneels, 2007; Gruber et al., 2012; Marino, 1996; Teece, 1982), capturing the extent to which the top management can identify the firm's technological resources and competences and understand their potential application to new uses. With regard to *market-related resource cognition*, eight items were generated according to prior work dealing with market-related resources and customer understanding (Danneels, 2003, 2011; Gruber, Heinemann, Brettel, & Hungeling, 2010; Marino, 1996), gauging the extent to which the top management can identify the firm's marketing resources and customer understanding and understand their fungibility.

Table 4.1: Operationalization of Managerial Resource Cognition

Technology-related Resource Cognition		Market-related Resource Cognition	
Prior related literature	Derived items	Prior related literature	Derived items
<ul style="list-style-type: none"> Identifying core technological resources and prioritizing R&D activities on the basis of the respective strengths and weaknesses (Marino, 1996: 44, 47). Recognizing technological resources in their own right uncoupled from specific products in which they are embodied (Danneels, 2007: 516). Establishing agreement and consensus on the firm's technology-based competences (Marino, 1996: 45). 	<p><i>TRC1</i>: Our top management knows about the firm's most important technical resources.</p> <p><i>TRC2</i>: Our top management is aware of the strengths and weaknesses of our R&D activities.</p> <p><i>TRC3</i>: Our top management views the firm's technologies independently from the products in which they are currently used.</p> <p><i>TRC4</i>: Among the top managers exists a shared understanding of our technical competences.</p>	<ul style="list-style-type: none"> Identifying and knowing those marketing resources that represent core assets of the firm (Marino, 1996: 44, 48). Identifying how the firm's marketing competences differ from those of its competitors (Marino, 1996: 50). Having a mental model of customers' preferences and habits, that is, having a customer understanding (Danneels, 2003: 565). 	<p><i>MRC1</i>: Our top management knows exactly what the most important marketing resources of the firm are.</p> <p><i>MRC2</i>: The top management can distinguish our marketing competences from that of our competitors.</p> <p><i>MRC3</i>: Our top managers have a very detailed understanding of our marketing activities.</p> <p><i>MRC4</i>: Our top management can pinpoint the customer understanding of the firm.</p>
<ul style="list-style-type: none"> Knowing whether it is possible to use specific technological resources for application domains other than the one(s) currently pursued (Gruber et al., 2012: 1434). Understanding the potential variety of products a certain technology can produce (Teece, 1982: 46). Considering how the firm's technological competences may be leveraged by applying them to other product areas (Danneels, 2007: 516). 	<p><i>TRC5</i>: Our top management knows which technical resources of the firm can be transferred to alternative areas of application.</p> <p><i>TRC6</i>: The top management knows which new product areas our technologies can be applied to.</p> <p><i>TRC7</i>: Our top management regularly considers how our R&D activities can be adapted to new applications.</p> <p><i>TRC8</i>: The potential applications of our technical competences are known to our top managers.</p>	<ul style="list-style-type: none"> Thinking about alternative configurations of marketing resources when restructuring marketing activities (Gruber et al., 2010: 1347). Knowing in which emerging product markets the firm's market-related resources have value (Marino, 1996: 44). Considering new product category entries based on a deep customer understanding (Danneels, 2011: 16). 	<p><i>MRC5</i>: Our top management has a conception of which new customers we can serve with our existing marketing resources.</p> <p><i>MRC6</i>: Our top management knows in which alternative product areas our marketing expertise can be used.</p> <p><i>MRC7</i>: Our top management knows how our marketing activities can be adapted to expand into new product markets.</p> <p><i>MRC8</i>: Our top management regularly considers how our customer understanding is transferable to other product areas.</p>

Note: Items printed in bold were retained after confirmatory factor analyses. Items not in bold were not considered for the main analyses.

The items were discussed with several management scholars who were versed in the respective literature and adapted if necessary to secure construct validity. Although originally formulated in English, the items were translated into German to guarantee that all participants understand them because English was not always the official language in the targeted firms. An independent professional translation office then translated the German items back into English (Brislin, 1980). Also, the items were pretested with several managers and a few items were further refined because respondents interpreted them differently from intended. Table 4.1 shows the operationalization of managerial resource cognition by indicating the list of items together with references from prior literature from which the items were derived for each component and dimension of resource cognition.

In a second step, after collecting the primary survey data, I applied exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to the data received from the first informants for the final sample ($n = 127$) to verify the factor structure and refine the scales (Worthington & Whittaker, 2006). With regard to sample size requirements for conducting factor analysis, the data are in line with what is suggested as sufficient in the literature (Klein, 2005; Reise, Waller, & Comrey, 2000; Worthington & Whittaker, 2006). Specifically, the respondents-to-items ratio is 7.94 to 1 and, thus, exceeds the recommended minimum ratio of 5 to 1 (Grimm & Yarnold, 1995; Hatcher, 1994). As a further prerequisite for factor analysis, the inter-item correlations were checked and they all exceeded the proposed threshold of 0.40 within the same subscale (Churchill, 1979; Hinkin, 1998). To confirm the factorability of the correlation matrix, I verified the Kaiser-Meyer-Olkin measure, which was 0.92 and clearly above the recommended minimum of 0.60, and I conducted the Bartlett's test of sphericity that yielded a significant result ($\chi^2 = 1749.26$, $df = 120$, $p < 0.001$) (Hair et al., 2010; Worthington & Whittaker, 2006).

I then conducted EFA to investigate the factor structure. I used principle axis factoring in SPSS as an extraction method instead of principle components analysis because principle axis factoring aims to reveal the latent structure of a set of items by extracting the least number of factors that account for the common variance among items (Conway & Huffcutt, 2003). Thus, it has been recommended as the preferred method for the development of new scales (Worthington & Whittaker, 2006). Regarding the rotation method, oblique rotation was applied rather than orthogonal rotation because the expected factors are assumed to be correlated due to the assumed complementarity between both components of resource cognition and this method avoids overestimations of factor loadings (Conway & Huffcutt, 2003; Worthington & Whittaker, 2006).

In particular, I chose the Promax option (with the default Kappa = 4 in SPSS) and referred to the Kaiser criterion proposing to retain as many factors as have an eigenvalue of 1 to determine the number of factors (Worthington & Whittaker, 2006). As shown in the factor pattern matrix (see Table 4.2), the EFA resulted in a clear two-factor solution reflecting the proposed subscales with loadings exceeding 0.50 for the respective factors and small cross-loadings (Hair et al., 2010). The two factors accounted for 65 percent of the total variance and all item communalities were larger than the recommended threshold of 0.40 (Worthington & Whittaker, 2006).

Table 4.2: Results of Exploratory Factor Analysis for Managerial Resource Cognition

Items	Extracted Factors		Communalities
	1	2	
TRC1	0.663	0.147	0.598
TRC2	0.747	0.016	0.575
TRC3	0.605	0.121	0.483
TRC4	0.781	0.074	0.696
TRC5	0.866	0.045	0.806
TRC6	0.972	-0.095	0.824
TRC7	0.702	0.060	0.555
TRC8	0.950	-0.044	0.846
MRC1	-0.049	0.855	0.674
MRC2	0.049	0.748	0.614
MRC3	-0.139	0.923	0.691
MRC4	0.108	0.698	0.604
MRC5	0.103	0.766	0.708
MRC6	0.154	0.643	0.576
MRC7	0.055	0.736	0.602
MRC8	0.266	0.527	0.546
Eigenvalue	9.438	1.300	

Note: Factor pattern matrix is reported with principal axis factoring using Promax rotation (Kappa=4). Numbers in bold indicate the two factors extracted. n = 127.

Taking the two-factor structure proven by EFA as a basis, I applied CFA with robust maximum likelihood estimation using Mplus 7 (Muthén & Muthén, 1998-2012) to test the overall model fit and refine the scale. I specified a model with two correlated factors, with each reflecting one of the two subscales, including all respective items. As items that share high levels of error covariance with other items can negatively influence a scale's psychometric properties (Hair et al., 2010; Netemeyer, Bearden, & Sharma, 2003), I assessed modification indices to identify problematic items. As a consequence, items *MRC2*, *TRC1*, *MRC7*, and *TRC6* were successively eliminated. However, the deletion of items was performed very cautiously, that is, an item was only deleted when it caused no loss of theoretical meaning to ensure that the deletion process was not solely guided by the statistics (Reise et al., 2000). The refined two-factor model fit the data very well ($\chi^2[53] = 62.33$, CFI = 0.99, TLI = 0.98, RMSEA = 0.04) regarding cutoff values recommended in the literature for model fit: Values above 0.95 for the comparative fit index (CFI) and Tucker-Lewis index (TLI) and values of 0.06 or lower for the root mean square error of approximation (RMSEA) indicate a good fit a model (Hu & Bentler, 1999). This two-factor model also had a much better fit than a model in which all items were loaded on only one factor ($\chi^2[54] = 166.17$, CFI = 0.85, TLI = 0.82, RMSEA = 0.13).

In the third and final step, I evaluated the validity of the scales. With regard to convergent validity, standardized factor loadings must be significant and should be greater than 0.50, ideally greater than 0.70 (Hair et al., 2010). The factor loadings of the two subscales were highly significant and above the recommended threshold, ranging from 0.71 to 0.91. The average variance extracted (AVE) was 0.66 and 0.62 for technology-related resource cognition and market-related resource cognition, respectively, clearly exceeding the suggested cutoff criteria of 0.50 (Bagozzi & Yi, 1988). The composite reliabilities (CRs) for the two factors were 0.92 and 0.91 and above the recommended threshold of 0.60 (Bagozzi & Yi, 1988). Regarding discriminant validity, each factor's AVE was larger than the squared value of the correlation between the two factors (Fornell & Larcker, 1981). Moreover, the two subscales demonstrated high levels of internal consistency: Cronbach's alpha for technology-related resource cognition was 0.92 and for market-related resource cognition it was 0.90. Table 4.3 summarizes the results of CFA and indicates the final scales for managerial resource cognition, the standardized factor loadings, and reliability values.

Table 4.3: Results of Confirmatory Factor Analysis for Managerial Resource Cognition

<i>Constructs and Items</i>	<i>Factor loadings</i>	<i>t-values</i>	<i>CR</i>	<i>AVE</i>	<i>Corr²</i>
<i>Technology-related Resource Cognition</i> ($\alpha = 0.92$)			0.92	0.66	0.58
Our top management is aware of the strengths and weaknesses of our R&D activities.	0.736	16.569			
Our top management views the firm's technologies independently from the products in which they are currently used.	0.708	11.913			
Among the top managers exists a shared understanding of our technical competences.	0.859	25.258			
Our top management knows which technical resources of the firm can be transferred to alternative areas of application.	0.899	36.080			
Our top management regularly considers how our R&D activities can be adapted to new applications.	0.742	13.013			
The potential applications of our technical competences are known to our top managers.	0.909	41.575			
<i>Market-related Resource Cognition</i> ($\alpha = 0.90$)			0.91	0.62	0.58
Our top management knows exactly what the most important marketing resources of the firm are.	0.772	19.836			
Our top managers have a very detailed understanding of our marketing activities.	0.765	16.657			
Our top management can pinpoint the customer understanding of the firm.	0.798	18.186			
Our top management has a conception of which new customers we can serve with our existing marketing resources.	0.861	27.232			
Our top management knows in which alternative product areas our marketing expertise can be used.	0.783	18.505			
Our top management regularly considers how our customer understanding is transferable to other product areas.	0.728	15.079			

Note: $n=127$. Corr^2 indicates the squared correlation between the constructs.

To account for the interdependence between technology-related and market-related resource cognition – affirmed by the high correlation between the respective factors ($r = 0.76$) – I added up the two components to form a combined, additive index of managerial resource cognition for use in regression analyses. This approach is consistent with research on ambidexterity that formed an index for ambidextrous orientation as the additive combination of exploratory and exploitative orientation of two interdependent scales (Lubatkin, Simsek, Ling, & Veiga, 2006). Also, consistent with this conceptualization of ambidexterity, other studies have formed a multiplicative score of exploration and exploitation (Gibson & Birkinshaw, 2004; Mihalache et al., 2014). Therefore, in a robustness analysis, I re-ran the regressions using a measure for resource cognition calculated as the multiplication of technology-related and market-related resource cognition. In addition, all regression analyses were conducted with technology-related and market-related resource cognition treated as separate independent variables to consider potential distinct effects of the two components.

Decentralization. Decentralization was measured with a five-item reverse-coded scale for centralization of decision-making adapted from Jansen et al. (2006). The scale captures the degree to which decision-making is distributed or concentrated in the firm by asking the first informants to refer their answers to their whole organization (see also Hage & Aiken, 1967). The reverse-coded items are: “There can be little action taken without a supervisor’s approval,” “A person who wants to make his own decisions will be quickly discouraged,” “Even small matters have to be referred to someone higher up for a final decision,” “Employees almost always need to ask their supervisor before they can do anything,” and “Most decisions employees make here have to have their supervisor’s approval.” This measure exhibited strong internal consistency ($\alpha = 0.92$).

To further validate the decentralization measure and to empirically demonstrate its distinctiveness from the subscales of resource cognition, an integrated CFA was performed in which the two factors for the components of resource cognition and a factor consisting of the five items for decentralization were correlated with one another. The resulting model indicated a good fit with the data ($\chi^2[116] = 155.21$, CFI = 0.97, TLI = 0.96, RMSEA = 0.05). Moreover, the measure for decentralization showed convergent validity with highly significant standardized factor loadings from 0.68 to 0.93, a CR value of 0.92, and an AVE of 0.71. In addition, discriminant validity was established, as the squared correlations that the factor for

decentralization had with the factors for the subscales for resource cognition (0.05 and 0.04) were lower than its AVE.

TMT size. Following common TMT definitions (Carpenter et al., 2004) and previous measurements of the size of a firm's top management (Carpenter, 2002; Wiersema & Bantel, 1992), TMT size was measured as the total number of members belonging to the very highest level of a firm's management, including the CEO and other chief officers, as well as the second highest level, including vice presidents and heads of specific functions and areas. The data were gathered from the Bureau van Dijk company databases AMADEUS and DAFNE. These databases list the members of the two highest management layers considering the names, position titles, and functional affiliations of those managers. For two firms, this information was directly collected from the annual reports because it was not available in the databases. Strictly administrative or support personnel, such as the chief secretary, who were also listed in some cases, were not counted so as to only include the main strategic decision-makers of a firm (cf. Boeker, 1997). As exact position titles of managers and their meaning (e.g., in terms of hierarchical position) can differ among firms, the focus on the two highest management levels represents an objective approach for measuring TMT size to achieve high consistency across the firms in the sample (Wiersema & Bantel, 1992).

Dependent variable: Firm growth. As explained above, firm growth has been suggested as an appropriate measure to assess the performance of a dynamic managerial capability (Helfat et al., 2007). Drawing on previous research (Baum, Calabrese, & Silverman, 2000; Fernhaber & Patel, 2012), I used a multidimensional measure for firm growth containing four indicators: sales growth, profit growth, market share growth, and growth in number of employees. The multidimensionality of the growth measure allows for considering various benefits of managerial resource cognition not only regarding growing sales but also in terms of market share expansions and profit increases (cf. Venkatraman & Ramanujam, 1986). However, objective figures for these indicators were difficult to obtain for all firms because most of the sample firms were privately held and respondents are usually unwilling to disclose quantitative performance data about their firm for reasons of confidentiality (Love, Priem, & Lumpkin, 2002). Therefore, I relied on a perceptual measure adapted from Eddleston et al. (2008) that is in line with the operationalization of other perceptual multi-item scales for firm performance (e.g., Lubatkin et al., 2006).

Specifically, the second informants were asked to rate the four growth indicators in comparison to their competitors on a seven-point Likert scale ranging from 1 for "much worse"

to 7 for “much better.” The resulting four-item scale demonstrated high construct reliability ($\alpha = 0.86$, CR = 0.86, AVE = 0.60) based on the ratings provided by all second informants of the final sample ($n = 240$). Through the comparison with competitors, the raters were given a reference point and the measurement indirectly controlled for performance variations that may be caused by industry or market-level effects (Dess & Robinson, 1984). Although objective figures for firm performance are preferred, perceptual performance ratings were found to highly correlate with the respective objective figures (Dess & Robinson, 1984; Engelen, Gupta, Strenger, & Brettel, 2015; Venkatraman & Ramanujam, 1986). Thus, they might represent a second best way to examine firm performance, especially when the “alternative is to remove the consideration of performance from the research design” (Dess & Robinson, 1984: 271). Moreover, subjective performance measures have been suggested as most appropriate when assessing the relative performance of firms within the same industry as is the case for this study (Dess & Robinson, 1984).

Nevertheless, I took several steps to corroborate the accuracy of the perceptual measurement. For a subset of 93 firms, I used information on firm growth from two to three second informants to minimize random measurement errors that can accompany single ratings (Ostroff, 1993). To determine the degree of interrater reliability, I computed the intraclass correlation coefficient (ICC) (Shrout & Fleiss, 1979). I obtained an ICC value of 0.45 (based on $n=206$ second informants), which is clearly greater than the minimum value of 0.10 that Bliese (1998) recommended and the median value of 0.12 found in the literature on organizational climate (James, 1982). The ICC obtained was also comparable to values reported in similar research (e.g., Schilke, 2014; Sutcliffe, 1994). Accordingly, the ICC indicated sufficient homogeneity in ratings among informants within firms and heterogeneity in ratings between firms (Dess & Robinson, 1984) and, thus, justified the aggregation of the second informants’ ratings to arithmetic means that are expected to yield more reliable judgements (LeBreton & Senter, 2007; Ostroff, 1993). These arithmetic means were included in the regression analyses for cases with more than one second informant.

I additionally gathered information on firm growth from the first informant to establish interrater reliability for all 127 firms in the sample on the basis of all $n = 367$ informants. The resulting ICC value of 0.43 further confirmed the measurement adequacy. More specifically, I also found adequate interrater reliability among first and second informants by constraining the analysis to the subset of 34 firms with only one second informant (ICC = 0.35). The correlation

between the ratings of both informants on firm growth was high and significant ($r = 0.41$, $p < 0.05$). Third, I cross-validated the perceptual growth measure with an objective measure for growth. For a subset of 79 firms, the one-year sales growth rate was collected from the first informant and it significantly correlated with the perceptual growth measure when using the single and aggregated ratings of the second informants ($r = 0.35$, $p < 0.01$) as well as when using the aggregated ratings of both the first and second informants ($r = 0.43$, $p < 0.001$). These results are consistent with similar cross-validations reported in prior research (e.g., Engelen et al., 2015).

Control variables. I considered several variables pertaining to environmental, firm, and TMT characteristics as control variables. *Firm size* may influence organizational structures (Miller & Dröge, 1986) as well as firm growth because larger companies may have more resources to deploy and a greater amount of means to foster new product or market initiatives (Schilke, 2014). Thus, I included firm size measured as the total number of employees. *Firm age*, measured as the number of years since the firm was founded, was considered because younger firms may be more entrepreneurial than older firms and may grow more strongly and rapidly (Autio, Sapienza, & Almeida, 2000). Both firm size and age were normalized using the natural logarithm for subsequent analyses. I also controlled for *firm profitability* to isolate differences in firm growth that are due to this variable (Mudambi & Swift, 2011) because more profitable firms might be better able to fund growth from profits (Eddleston et al., 2008). Moreover, better performing firms may also attract more highly skilled managers. I measured firm profitability with one item asking the first informant to rate the firm's profitability relative to competitors on a scale from 1 for "much worse" to 7 for "much better."

TMT composition may also affect strategic decision-making and firm outcomes (Carpenter et al., 2004). Thus, a top management's capacity to understand and appropriately orchestrate the firm's technology and market-related resources might be affected by the number of top managers directly assigned a position focused on technological and/or market activities. Therefore, I included the *proportion of technology-related top managers* (e.g., chief technology officer, vice president R&D) and the *proportion of market-related top managers* (e.g., chief marketing officer, vice president sales) calculated as the number of technology-related and market-related top managers, respectively, divided by the total number of top managers. As organizational design variables other than decentralization can influence the information flow within a firm, I also controlled for two further structural elements that have been emphasized in the study of strategic decision-making (Miller, 1987). I included *formalization* with a four-item scale ($\alpha = 0.74$)

adapted from Jansen et al. (2006). I considered *integration mechanisms* adapted from Zahra and Nielsen (2002) and measured as an index consisting of a four-item scale capturing formal integration ($\alpha = 0.86$) and a four-item scale reflecting informal integration ($\alpha = 0.85$). All multi-item control variables are displayed in Appendix 4.

The current availability and quality of firm resources may affect top managers' resource cognition and therefore the direction of firm growth (Mahoney, 1995). In a similar vein, important knowledge-based resources, such as technical and market expertise, may enable a firm to explore and exploit new growth opportunities (Wiklund & Shepherd, 2003). Thus, I included the four-item scale ($\alpha = 0.93$) *technical expertise*, which was adapted from existing scales (Matusik & Heeley, 2005; Wiklund & Shepherd, 2003) and mirrors the technical expertise and skills of a firm's knowledge workers. I also considered *market expertise* with a five-item scale ($\alpha = 0.91$) partly adapted from Wiklund and Shepherd (2003) and partly based on theoretical propositions by Shane (2000) to gauge the knowledge workers' marketing expertise and knowledge about customers. This information was gathered from the second informants.

The degree of environmental changes may influence how top managers make strategic decisions (Larrañeta, Zahra, & Galán González, 2014) and can affect firm growth (Baum & Wally, 2003). Hence, I controlled for *environmental dynamism* using a three-item scale ($\alpha = 0.85$) adapted from Jansen et al. (2006). Since firm growth can also vary with market and product segment (Baum et al., 2000), I considered five different *medical technology segments* in which the firms in the sample primarily operate. I used dummy variables for these segments according to business descriptions of the firms that were available in general company databases and/or industry-specific databases provided by medical technology associations. The dummies included (1) surgical, diagnostic, and therapeutic devices and systems (used as the reference category), (2) medical aids and implants, (3) lab technology and diagnostics, (4) dental products and instruments, and (5) medical furniture.

4.5 ANALYSES AND RESULTS

Table 4.4 reports the descriptive statistics and the bivariate correlations among the study's variables (not including the segment dummies). The mean value of market-related resource cognition (4.93) is slightly higher than that of technology-related resource cognition (4.82). However, the two components are highly correlated ($r = 0.71$, $p < 0.001$), confirming their high interrelatedness and justifying the addition of the two components to form an additive score for (overall) resource cognition. Moreover, the results reveal that a high degree of decentralization comes along with a larger TMT indicated by the positive and significant correlation between the two variables ($r = 0.22$, $p < 0.05$). The average TMT size was 5.62, ranging from 1 to 12 members.

Test of the Hypotheses

To test the study's hypotheses, I performed hierarchical ordinary least squares (OLS) regression analyses, which are presented in Table 4.5. For these calculations, SPSS 21 was applied with Hayes and Cai's (2007) macro for robust standard errors. Specifically, the HC4 estimator was used, which is robust against high leverage observations and non-normal errors (Cribari-Neto, 2004). In a first step (Model 1), the control variables were inserted in the regression, serving as the baseline model. In a second step (Model 2), the main effects of all central variables (resource cognition, decentralization, and TMT size) were included. In a third step (Model 3), not only was the hypothesized interaction between resource cognition and decentralization included, but also the other two possible two-way interactions were inserted as recommended in the literature (Allison, 1977). Last, in a fourth step (Model 4), the three-way interaction term was added. To reduce potential multicollinearity, the independent and interaction variables were mean centered (Aiken & West, 1991). Nevertheless, I calculated the variance inflation factor (VIF) for all variables to diagnose whether multicollinearity may still cause a problem. As all VIF scores were below 2, ranging from 1.08 to 1.91, multicollinearity is unlikely to be an issue (Hair et al., 2010). Moreover, the improvement between the different models was assessed. The findings show that in the hierarchical order from one model to the next the R squared increased.

Table 4.4: Descriptive Statistics and Correlations

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Firm growth	4.48	0.80															
2. Resource cognition (RC)	9.75	2.24	0.31***														
3. Technology-related RC	4.82	1.32	0.24**	0.94***													
4. Market-related RC	4.93	1.09	0.34***	0.91***	0.71***												
5. Decentralization	4.99	1.40	0.14**	0.22*	0.23*	0.18*											
6. TMT size	5.62	2.83	-0.05	-0.05	-0.09	0.02	0.22*										
7. Firm size	5.55	1.46	0.14	0.06	0.04	0.08	-0.01	0.30**									
8. Firm age	3.66	0.87	-0.10	0.12	0.07	0.16†	-0.07	0.15	0.28**								
9. Firm profitability	4.69	1.25	0.33***	0.16†	0.10	0.20*	0.16†	0.03	0.14	0.14							
10. Proportion tech.-related top managers	0.15	0.13	-0.04	0.02	-0.02	0.07	0.11	0.48***	-0.08	0.03	0.04						
11. Proportion market-related top managers	0.19	0.18	-0.08	0.07	0.07	0.04	0.05	-0.12	-0.28**	-0.15†	-0.02	0.00					
12. Formalization	4.80	1.30	-0.01	0.12	0.10	0.12	-0.21*	0.03	0.24**	0.08	-0.03	-0.14	-0.12				
13. Integration mechanisms	4.83	0.96	0.10	0.54***	0.49***	0.51***	0.20*	0.05	0.02	0.14	0.17†	-0.02	0.02	0.24**			
14. Technical expertise	5.52	0.99	0.27**	0.12	0.09	0.13	0.12	0.04	0.18*	-0.07	0.16†	0.05	0.01	0.22*	0.16†		
15. Market expertise	4.59	1.05	0.25**	0.21*	0.17†	0.22*	0.14	-0.08	0.06	0.02	0.16†	-0.03	0.02	0.17†	0.29**	0.53***	
16. Environmental dynamism	4.54	1.37	0.15†	0.24**	0.20*	0.26**	-0.06	0.13	0.23**	0.20*	-0.01	0.05	-0.19*	0.25**	0.29**	0.12	0.10

Note: For multi-item constructs, the item averages are used. n = 127. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Two-tailed tests.

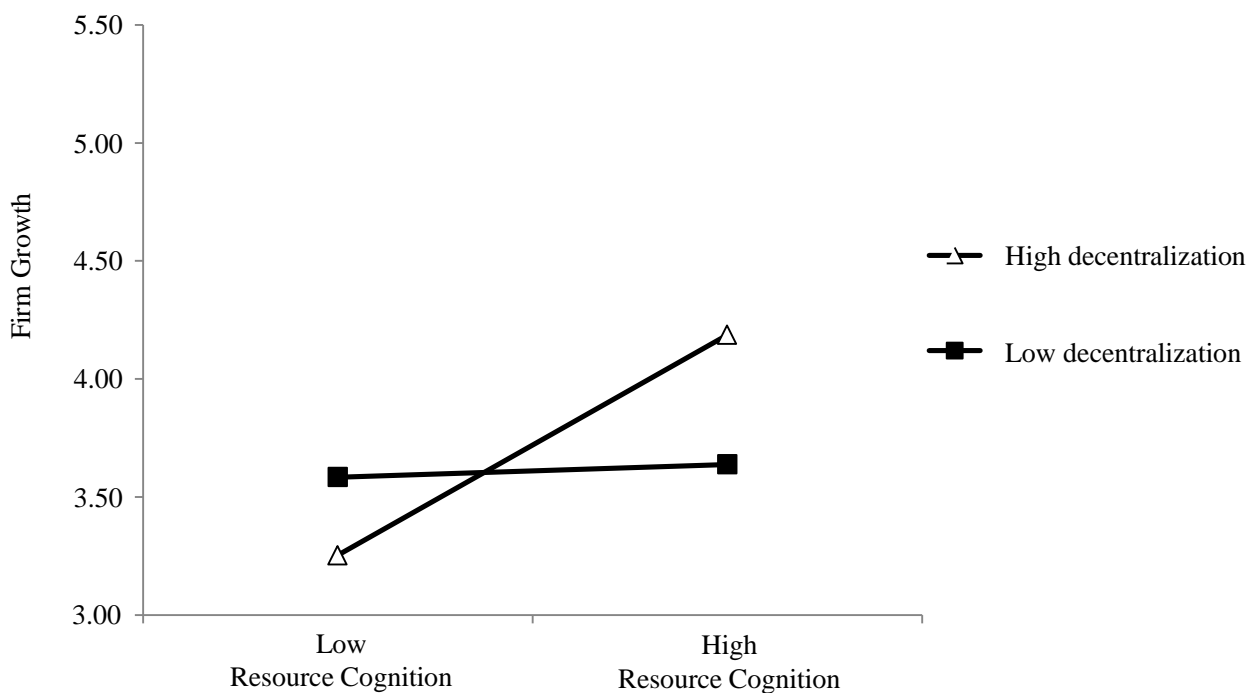
Table 4.5: Results of Main Analyses

Variables	Model 1	Model 2	Model 3	Model 4
Resource cognition (additive score) ^a		0.1063*	0.1104*	0.1230**
		(0.0449)	(0.0436)	(0.0406)
Decentralization ^a		0.0166	0.0392	0.0318
		(0.0525)	(0.0508)	(0.0482)
TMT size ^a		-0.0087	-0.0044	0.0031
		(0.0324)	(0.0332)	(0.0328)
Resource cognition × decentralization			0.0707**	0.0716**
			(0.0258)	(0.0214)
Resource cognition × TMT size			-0.0318*	-0.0230*
			(0.0122)	(0.0101)
Decentralization × TMT size			0.0232	0.0172
			(0.0180)	(0.0158)
Resource cognition × decentralization × TMT size				-0.0181*
				(0.0071)
Firm size	0.0486	0.0443	0.0669	0.0787
	(0.0468)	(0.0575)	(0.0491)	(0.0538)
Firm age	-0.1564†	-0.1707*	-0.2178**	-0.2308**
	(0.0837)	(0.0795)	(0.0767)	(0.0779)
Firm profitability	0.1841**	0.1745**	0.1986***	0.1970***
	(0.0591)	(0.0569)	(0.0573)	(0.0549)
Proportion technology-related top managers	-0.4852	-0.4553	-0.4237	-0.3358
	(0.5844)	(0.6382)	(0.5907)	(0.5813)
Proportion market-related top managers	-0.3066	-0.4312	-0.4078	-0.4609
	(0.6949)	(0.6295)	(0.4678)	(0.4214)
Formalization	-0.0613	-0.0526	-0.0585	-0.0618
	(0.0612)	(0.0591)	(0.0572)	(0.0541)
Integration mechanisms	-0.0169	-0.1374	-0.1928*	-0.1860*
	(0.0797)	(0.1001)	(0.0938)	(0.0903)
Technical expertise	0.1144	0.1089	0.1077	0.0931
	(0.0835)	(0.0818)	(0.0817)	(0.0812)
Market expertise	0.1037	0.0866	0.1375†	0.1521†
	(0.0931)	(0.0876)	(0.0808)	(0.0785)
Environmental dynamism	0.0950†	0.0833	0.0755	0.0633
	(0.0503)	(0.0506)	(0.0478)	(0.0468)
Medtech segment (2)	0.1422	0.1323	0.0394	0.0181
	(0.1543)	(0.1456)	(0.1395)	(0.1379)
Medtech segment (3)	0.0990	0.1145	0.1233	0.0926
	(0.2253)	(0.2291)	(0.2076)	(0.1989)
Medtech segment (4)	-0.2995	-0.0873	-0.2245	-0.2325
	(0.1967)	(0.2107)	(0.2289)	(0.2142)
Medtech segment (5)	-0.0803	0.0021	0.0775	0.0721
	(0.3423)	(0.3411)	(0.2685)	(0.2991)
<i>F</i>	3.6397***	4.1070***	6.1361***	6.4659***
<i>R</i> ²	0.2522	0.3117	0.3951	0.4236
ΔR^2		0.059*	0.083**	0.028*

Note: Regression analysis with firm growth as the dependent variable. n = 127. Unstandardized coefficients reported with robust standard errors in parentheses. ^a Variables mean-centered. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Two-tailed tests.

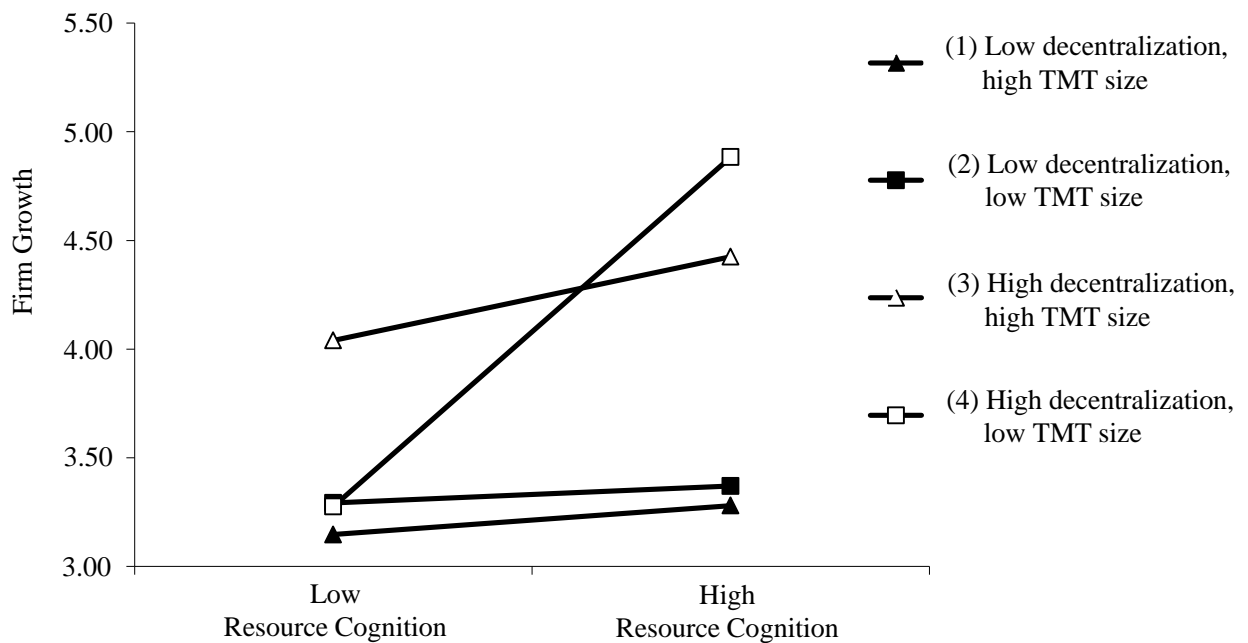
With respect to the main effect (see Model 2), Hypothesis 1 is supported because managerial resource cognition (measured as the additive score of technology and market-related resource cognition) is positively and significantly related to firm growth (0.11, $p < 0.05$). In line with Hypothesis 2 (i.e., decentralization positively moderates the relationship between resource cognition and firm growth), the two-way interaction effect of resource cognition with decentralization, as shown in Model 3, is positive and significant (0.07, $p < 0.01$). Furthermore, simple slope tests and interaction plots were conducted to examine the form of the moderation effect as described by Aiken and West (1991) by using a software tool provided by Sibley (2008). The effect of resource cognition was computed at one standard deviation below and above the mean of the moderating variable (i.e., decentralization). When decentralization is high, resource cognition is positively associated with firm growth (0.21, $p < 0.001$). In contrast, when decentralization is low, this relationship is not significant (0.01, $p > 0.10$). Figure 4.2 illustrates these results.

Figure 4.2: Two-Way Interaction with Firm Growth as Dependent Variable



With regard to the three-way interaction in Model 4, the effect is significant, but contrary to Hypothesis 3 that suggests a positive interaction among resource cognition, decentralization, and TMT size, this effect is negative (-0.02 , $p < 0.05$). To further interpret this finding, I performed simple slope tests and plotted the interaction at high and low levels of the three variables set at one standard deviation below and above their mean values (Aiken & West, 1991; Sibley, 2008). The slope where resource cognition and decentralization are both high but TMT size is low is the only slope that is positive and significantly different from zero (0.36 , $p < 0.001$). The other slopes reflecting other possible combinations are not significant. Specifically, the hypothesized combination where resource cognition, decentralization, and TMT size are all high is, although positive, non-significant (0.09 , $p > 0.10$). As illustrated in Figure 4.3, the marginal effect of resource cognition on firm growth is highest when decentralization is high and TMT size is low – represented by slope (4).

Figure 4.3: Three-Way Interaction with Firm Growth as Dependent Variable



As Dawson and Richter (2006) recommended, I ran slope difference tests to assess whether this slope was also significantly different from the other slopes. Table 4.6 reports the t-values and p-values for slope differences for each pairwise comparison as computed with Sibley's (2008) tool. As shown, slope (4) is significantly different from slopes (1), (2), and (3). Taking all these results together, Hypothesis 3 is rejected. In contrast, I found that the three-way interaction effect has a negative sign and the relationship between resource cognition and firm growth is strongest when the degree of decentralization is high and TMT size is small. This surprising and somewhat counterintuitive finding is further examined in the following robustness checks section and discussed in the discussion section.

Table 4.6: Slope Differences for the Three-Way Interaction

Pair of slopes	t-value for slope difference	p-value for slope difference
(1) and (2)	0.135	0.893
(1) and (3)	0.840	0.403
(1) and (4)	4.047	0.000
(2) and (3)	0.817	0.416
(2) and (4)	3.638	0.000
(3) and (4)	-3.961	0.000

Robustness Checks and Post-Hoc Analyses

To prove the robustness of the results obtained above, I conducted several extra analyses. First, I re-ran the regressions using a multiplicative score for resource cognition (i.e., multiplying the two components of technology-related and market-related resource cognition). The multiplicative approach represents an alternative means of accounting for the interdependence of the two components (cf. Gibson & Birkinshaw, 2004; Mihalache et al., 2014). The results of the multiplicative score are consistent with those obtained in the main analyses using the additive score for resource cognition.

As shown in Table 4.7, these additional results confirm Hypothesis 1 and Hypothesis 2. In particular, simple slope tests regarding the two-way interaction reveal that, when decentralization is high, resource cognition is positively related to firm growth (0.04, $p < 0.001$), but this relationship is non-significant when decentralization is low (0.00, $p > 0.10$). The results in Model 4 also replicate the significant and negative three-way interaction effect that led to a finding contrary to what was expected in Hypothesis 3. As found in the main analyses, the slope with resource cognition and decentralization at high levels and TMT size at low levels was the only significant slope (0.07, $p < 0.001$) and the slope difference tests yielded very similar findings. For both the two-way and three-way interaction, the graphic representations strongly resembled those depicted in the main figures.

Second, I verified the robustness of the results of the main analyses by also including the data on firm growth obtained from the first informant. Specifically, I aggregated all ratings available from both the first and the second informants to form an arithmetic mean for firm growth and re-ran the regression models. The results are reported in Table 4.8 and they correspond to those obtained in the main analyses.

Third, I conducted additional regression analyses treating technology-related resource cognition and market-related resource cognition as separate independent variables to account for the two components' potential distinct effects. As indicated in Table 4.9, the two variables were entered simultaneously in the main effects model (Model 2). However, the interaction effects of the two independent variables with decentralization and TMT size were inserted separately (see Model 3a through Model 4b), as the respective interaction terms are highly correlated with one another due to the inclusion of common variables and the already high correlation between the

two independent variables. In doing so, I reduced potential problems related to multicollinearity and it was easier to ascertain the particular effects of each (Aiken & West, 1991).

With regard to the main effects, market-related resource cognition has a positive and significant effect on firm growth (0.25, $p < 0.05$), whereas the effect of technology-related resource cognition is non-significant (-0.00, $p > 0.10$). A potential interpretation is that while it is not sufficient for managers to address technological resources for their firm to grow, it is always important for them to know and understand the market-related resources because it is through these resources that technologies are exploited and products or services are marketed. Concerning the two-way interactions, both technology (0.11, $p < 0.05$) and market-related (0.11, $p < 0.01$) resource cognition interacts with decentralization to positively influence firm growth. This may indicate that in a decentralized organization it is more likely that top managers' cognition about the firms' technologies will lead to growth, even if they lack sufficient market-related resource cognition, because in a decentralized organization more decisions are delegated to lower level employees who might be more engaged to ensure the marketing of technologies.

With respect to the three-way interactions, only the interaction effect of technology-related resource cognition with decentralization and TMT size is significant and negative (-0.03, $p < 0.01$). Although speculative, this finding may indicate that smaller TMTs with high technology-related resource cognition and good availability of high-quality information due to a high degree of decentralization may be more effective than larger TMTs. This is because within smaller TMTs it is easier to communicate, reach consensus, and decide on technology-related aspects that might be more complex and specialized than market-related aspects. In sum, when treating technology and market-related resource cognition as separate variables and when considering their main and various interaction effects, none of the components produces significant effects on firm growth across all models. As revealed in the analyses above, only resource cognition as a combined construct (as either an additive or multiplicative score) has a significant influence on firm growth across all situations, thus further corroborating the complementarity of technology and market-related resource cognition.

Table 4.7: Regression Results with Multiplicative Score for Resource Cognition

Variables	Model 1	Model 2	Model 3	Model 4
Resource cognition (multiplicative score) ^a		0.0218* (0.0095)	0.0221* (0.0091)	0.0240** (0.0090)
Decentralization ^a		0.0123 (0.0531)	0.0394 (0.0522)	0.0337 (0.0505)
TMT size ^a		-0.0077 (0.0330)	-0.0057 (0.0333)	0.0016 (0.0338)
Resource cognition × decentralization			0.0143** (0.0051)	0.0136** (0.0046)
Resource cognition × TMT size			-0.0061** (0.0022)	-0.0040† (0.0022)
Decentralization × TMT size			0.0223 (0.0176)	0.0157 (0.0161)
Resource cognition × decentralization × TMT size				-0.0035* (0.0015)
Firm size	0.0486 (0.0468)	0.0445 (0.0586)	0.0704 (0.0499)	0.0780 (0.0544)
Firm age	-0.1564† (0.0837)	-0.1593† (0.0809)	-0.2100** (0.0773)	-0.2170** (0.0790)
Firm profitability	0.1841** (0.0591)	0.1744** (0.0574)	0.1953*** (0.0567)	0.1930*** (0.0552)
Proportion technology-related top managers	-0.4852 (0.5844)	-0.4925 (0.6489)	-0.4146 (0.6081)	-0.3340 (0.5997)
Proportion market-related top managers	-0.3066 (0.6949)	-0.4331 (0.6298)	-0.4291 (0.4794)	-0.4742 (0.4476)
Formalization	-0.0613 (0.0612)	-0.0548 (0.0593)	-0.0577 (0.0566)	-0.0603 (0.0548)
Integration mechanisms	-0.0169 (0.0797)	-0.1358 (0.0999)	-0.1959* (0.0924)	-0.1816* (0.0905)
Technical expertise	0.1144 (0.0835)	0.1128 (0.0809)	0.1039 (0.0824)	0.0891 (0.0821)
Market expertise	0.1037 (0.0931)	0.0912 (0.0875)	0.1450† (0.0810)	0.1555† (0.0802)
Environmental dynamism	0.0950† (0.0503)	0.0791 (0.0516)	0.0707 (0.0489)	0.0598 (0.0479)
Medtech segment (2)	0.1422 (0.1543)	0.1303 (0.1459)	0.0317 (0.1418)	0.0143 (0.1413)
Medtech segment (3)	0.0990 (0.2253)	0.1144 (0.2295)	0.1153 (0.2087)	0.0864 (0.2024)
Medtech segment (4)	-0.2995 (0.1967)	-0.1009 (0.2104)	-0.2385 (0.2217)	-0.2465 (0.2151)
Medtech segment (5)	-0.0803 (0.3423)	0.0148 (0.3446)	0.0435 (0.2711)	0.0327 (0.3015)
<i>F</i>	3.6397***	4.0150***	6.2367***	5.3357***
<i>R</i> ²	0.2522	0.3098	0.3904	0.4125
ΔR^2		0.058*	0.081**	0.022*

Note: Regression analysis with firm growth as the dependent variable. n = 127. Unstandardized coefficients reported with robust standard errors in parentheses. ^a Variables mean-centered. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Two-tailed tests.

Table 4.8: Regression Results with Firm Growth obtained from First and Second Informants

Variables	Model 1	Model 2	Model 3	Model 4
Resource cognition (additive score) ^a		0.1087** (0.0365)	0.1133** (0.0345)	0.1224*** (0.0315)
Decentralization ^a		0.0141 (0.0439)	0.0312 (0.0412)	0.0258 (0.0402)
TMT size ^a		-0.0092 (0.0275)	-0.0054 (0.0275)	0.0001 (0.0283)
Resource cognition × decentralization			0.0526** (0.0181)	0.0533** (0.0180)
Resource cognition × TMT size			-0.0276** (0.0091)	-0.0212* (0.0100)
Decentralization × TMT size			0.0205 (0.0135)	0.0161 (0.0131)
Resource cognition × decentralization × TMT size				-0.0132* (0.0062)
Firm size	0.0488 (0.0447)	0.0446 (0.0461)	0.0614 (0.0432)	0.0700 (0.0444)
Firm age	-0.1696* (0.0763)	-0.1839** (0.0688)	-0.2191** (0.0673)	-0.2285** (0.0691)
Firm profitability	0.2393*** (0.0562)	0.2296*** (0.0521)	0.2496*** (0.0512)	0.2485*** (0.0508)
Proportion technology-related top managers	-0.2422 (0.4861)	-0.2070 (0.5238)	-0.2002 (0.5143)	-0.1362 (0.5132)
Proportion market-related top managers	0.1321 (0.4903)	0.0047 (0.4229)	0.0337 (0.3270)	-0.0049 (0.3011)
Formalization	-0.0449 (0.0485)	-0.0368 (0.0484)	-0.0412 (0.0460)	-0.0436 (0.0448)
Integration mechanisms	0.0538 (0.0703)	-0.0683 (0.0828)	-0.1175 (0.0799)	-0.1125 (0.0760)
Technical expertise	0.0835 (0.0682)	0.0783 (0.0645)	0.0778 (0.0597)	0.0672 (0.0587)
Market expertise	0.1530* (0.0733)	0.1357* (0.0670)	0.1773** (0.0601)	0.1879** (0.0601)
Environmental dynamism	0.1133* (0.0460)	0.1010* (0.0434)	0.0974* (0.0419)	0.0885* (0.0417)
Medtech segment (2)	0.1106 (0.1415)	0.1021 (0.1299)	0.0239 (0.1253)	0.0084 (0.1254)
Medtech segment (3)	0.0950 (0.1713)	0.1120 (0.1713)	0.1152 (0.1555)	0.0928 (0.1508)
Medtech segment (4)	-0.1841 (0.1901)	0.0323 (0.1803)	-0.0805 (0.1890)	-0.0863 (0.1884)
Medtech segment (5)	-0.2301 (0.3570)	-0.1459 (0.3873)	-0.0818 (0.3318)	-0.0857 (0.3527)
<i>R</i> ²	0.3830	0.4495	0.5070	0.5232
<i>F</i>	6.1784***	7.1525***	9.4582***	

Note: Regression analysis with firm growth as the dependent variable. n = 127. Unstandardized coefficients reported with robust standard errors in parentheses. ^a Variables mean-centered. † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001. Two-tailed tests.

Table 4.9: Regression Results using Technology and Market-Related Resource Cognition Independently

Variables	Model 1	Model 2	Model 3A	Model 3B	Model 4A	Model 4B
Technology-related RC ^a		-0.0024 (0.0797)	0.0487 (0.0791)	0.0042 (0.0701)	0.0936 (0.0716)	0.0039 (0.0695)
Market-related RC ^a		0.2455* (0.1023)	0.1913* (0.0997)	0.2404* (0.0928)	0.1652† (0.0936)	0.2565** (0.0892)
Decentralization ^a		0.0258 (0.0518)	0.0515 (0.0516)	0.0319 (0.0495)	0.0362 (0.0478)	0.0312 (0.0486)
TMT size ^a		-0.0141 (0.0317)	-0.0142 (0.0335)	-0.0008 (0.0319)	-0.0032 (0.0339)	0.0014 (0.0321)
Technology-related RC × decentralization			0.1071* (0.0418)		0.1072*** (0.0308)	
Market-related RC × decentralization				0.1138** (0.0417)		0.1146** (0.0414)
Technology-related RC × TMT size			-0.0391* (0.0187)		-0.0285† (0.0150)	
Market-related RC × TMT size				-0.0678* (0.0270)		-0.0535* (0.0262)
Decentralization × TMT size			0.0218 (0.0183)	0.0136 (0.0171)	0.0131 (0.0154)	0.0128 (0.0162)
Technology-related RC × Decentralization × TMT size					-0.0321** (0.0114)	
Market-related RC × Decentralization × TMT size						-0.0241 (0.0167)
Firm size	0.0486 (0.0468)	0.0476 (0.0550)	0.0643 (0.0483)	0.0645 (0.0494)	0.0755 (0.0509)	0.0712 (0.0539)
Firm age	-0.1564† (0.0837)	-0.1827* (0.0760)	-0.2147** (0.0760)	-0.2258** (0.0718)	-0.2284** (0.0776)	-0.2286** (0.0729)
Firm profitability	0.1841** (0.0591)	0.1623** (0.0589)	0.1739** (0.0583)	0.1993** (0.0597)	0.1702** (0.0568)	0.2015*** (0.0589)
Proportion tech.-related top managers	-0.4852 (0.5844)	-0.5041 (0.6318)	-0.2741 (0.6083)	-0.7420 (0.5864)	-0.1246 (0.6041)	-0.7238 (0.5771)
Proportion market-related top managers	-0.3066 (0.6949)	-0.4323 (0.6077)	-0.5023 (0.4995)	-0.3030 (0.4595)	-0.6010 (0.4533)	-0.2986 (0.4374)
Formalization	-0.0613 (0.0612)	-0.0504 (0.0595)	-0.0582 (0.0567)	-0.0512 (0.0583)	-0.0584 (0.0543)	-0.0561 (0.0567)
Integration mechanisms	-0.0169 (0.0797)	-0.1391 (0.1022)	-0.1785† (0.0966)	-0.1917* (0.0957)	-0.1619† (0.0915)	-0.1958* (0.0968)
Technical expertise	0.1144 (0.0835)	0.1091 (0.0831)	0.0955 (0.0845)	0.1215 (0.0809)	0.0737 (0.0863)	0.1189 (0.0795)
Market expertise	0.1037 (0.0931)	0.0777 (0.0869)	0.1243 (0.0849)	0.1126 (0.0791)	0.1410† (0.0839)	0.1219 (0.0791)
Environmental dynamism	0.0950† (0.0503)	0.0789 (0.0507)	0.0713 (0.0488)	0.0762 (0.0498)	0.0537 (0.0478)	0.0748 (0.0491)
Medtech segment dummies	Included	Included	Included	Included	Included	Included
R ²	0.2522	0.3298	0.3877	0.3985	0.4190	0.4099
F	3.6397***	4.4120***	5.8220***	5.5025***	8.2211***	6.0221***

Note: Regression analysis with firm growth as the dependent variable. n = 127. Unstandardized coefficients reported with robust standard errors in parentheses. ^a Variables mean-centered. † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001. Two-tailed tests.

Fourth, I further explored the findings for the negative three-way interaction. Specifically, I used subgroup analysis (Aiken & West, 1991; Dawson & Richter, 2006) and split the sample at the median value for TMT size (6.00) to form two groups: one below the median representing firms with smaller TMTs ($n = 63$) and one greater than or equal to the median representing firms with larger TMTs ($n = 64$). I then examined the two-way interaction of resource cognition with decentralization (Model 3) for each subgroup separately. As indicated in Table 4.10, only in the subgroup with smaller TMTs is the two-way interaction positive and significant (0.12, $p < 0.01$), confirming the unexpected finding that firms with smaller TMTs and high degrees of resource cognition and decentralization perform better in terms of firm growth.

Moreover, to rule out the possibility that the results are (partly) driven by a few cases with a top management consisting of only one member, I re-ran the regressions by excluding those cases, six in total (cf. Simsek et al., 2005). For the remaining $n = 121$ firms, the results of the regression analysis (with unstandardized coefficients and robust standard errors [SEs]) are consistent with those obtained for the full sample. In particular, the main effect of resource cognition on firm growth is positive and significant (0.09, $SE = 0.04$, $p < 0.05$), the two-way interaction effect of resource cognition with decentralization on firm growth is positive and significant (0.07, $SE = 0.03$, $p < 0.05$), and the three-way interaction effect among resource cognition, decentralization, and TMT size on firm growth is negative and significant (-0.02 , $SE = 0.01$, $p < 0.05$).

To identify what can be considered an optimally small TMT size, I applied the Johnson-Neyman technique on the full sample ($n = 127$) using the PROCESS macro for SPSS developed by Hayes (2012) with the HC3 estimator (because the HC4 estimator was not available for this tool). This technique allows for detecting regions of the values for a moderating variable where the interaction effect is significant (cf. Hayes, 2012; Paruchuri & Misangyi, 2015). I found that the interaction effect of resource cognition with decentralization on firm growth becomes significant below a value of 7.25 for TMT size. In other words, managerial resource cognition may be most effective in decentralized organizations and with TMTs containing seven members or less – at least in the context of this study.

Table 4.10: Results of Subgroup Analyses

Variables	Model 3	
	<i>TMT size < 6.00</i> <i>n = 63</i>	<i>TMT size ≥ 6.00</i> <i>n = 64</i>
Resource cognition (additive score) ^a	0.1978** (0.0695)	0.0689 (0.0681)
Decentralization ^a	-0.0002 (0.0903)	0.0473 (0.0757)
Resource cognition × decentralization	0.1160** (0.0412)	0.0140 (0.0367)
TMT size	-0.0279 (0.1281)	0.0599 (0.0726)
Firm size	0.0356 (0.0882)	0.0875 (0.1462)
Firm age	-0.0298 (0.1154)	-0.4054*** (0.1095)
Firm profitability	0.2084* (0.0950)	0.1121 (0.0817)
Proportion technology-related top managers	-0.4152 (1.1117)	0.0586 (0.8830)
Proportion market-related top managers	-0.6613 (0.5199)	0.9315 (1.7250)
Formalization	0.0358 (0.0920)	-0.0636 (0.0800)
Integration mechanisms	-0.3032† (0.1613)	-0.1187 (0.1742)
Technical expertise	0.0958 (0.1415)	0.0443 (0.1416)
Market expertise	0.1911† (0.0982)	0.1737 (0.1308)
Environmental dynamism	0.0660 (0.0835)	-0.0223 (0.0645)
Medtech segment (2)	0.2026 (0.2440)	-0.2323 (0.2205)
Medtech segment (3)	0.3372 (0.2810)	-0.2203 (0.2205)
Medtech segment (4)	-0.6206 (0.4544)	-0.4302 (0.3542)
Medtech segment (5)	-0.1706 (0.3462)	0.5562 (0.3805)
<i>R</i> ²	0.5283	0.4525
<i>F</i>	5.9957***	5.7093***

Note: Regression analysis with firm growth as the dependent variable. Unstandardized coefficients reported with robust standard errors in parentheses. ^a Variables mean-centered.

† $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Two-tailed tests.

Finally, to rule out endogeneity issues due to the cross-sectional data (e.g., caused by omitted variable bias), the inclusion of so-called “instruments” reflecting exogenous origins of variance uncorrelated with error terms is proposed (Antonakis et al., 2010). In the context of this study, however, I was unable to collect and include adequate instruments. Nevertheless, I employed several measures to enhance the inferences drawn from this study (cf. Antonakis et al., 2010; Antonakis, Bendahan, Jacquart, & Lalive, 2014). (1) To alleviate potential concerns regarding common method bias, I gathered data from an array of information sources involving top and senior managers, core knowledge workers, and secondary databases. (2) To mitigate potential problems related to omitted variable bias, I considered a long list of meaningful control variables. Specifically, I included firm profitability which is likely a common determinant for both top managers’ resource cognition and firm growth. In so doing, I reduced the potential for a spurious association between resource cognition and firm growth.

(3) To readjust for possible inconsistency in inference, I employed robust standard errors in all regressions (Antonakis et al., 2010). (4) I re-ran the analysis for the main effect by accounting for the measurement bias in the measure of resource cognition. I applied structural equation modeling with robust maximum-likelihood estimation (using Mplus 7) and regressed firm growth on a latent second-order construct consisting of the two components of resource cognition with the respective items including measurement error for every single indicator (Antonakis et al., 2014). I obtained a positive and highly significant standardized coefficient for the path between the second-order construct and firm growth (0.32, SE = 0.09, $p < 0.001$), while controlling for firm age, firm size, firm profitability, TMT size, and industry segment. Moreover, this model fit the data well ($\chi^2[160] = 185.87$, CFI = 0.97, TLI = 0.97, RMSEA = 0.04). These results further strengthen the inference regarding Hypothesis 1.

4.6 DISCUSSION

Drawing on the Penrosian view and the dynamic managerial capabilities approach, the purpose of this study was to further conceptualize and operationalize the concept of resource cognition first introduced by Danneels (2011) and to explore the performance implications of this managerial capability, as well as the organizational conditions under which it is most effective. The empirical data revealed that top managers’ cognitions about the firm’s technology- and market-related resources jointly lead to firm growth and that decentralization strengthens this association. The results also indicated that the interaction of resource cognition with decentralization is highest

when the size of the TMT is small rather than large. My study provides interesting implications for development of the concept of resource cognition as well as for research into dynamic managerial capabilities and the role of organizational design in the microfoundations of competitive advantage.

Organizational Self-Awareness and Managerial Resource Cognition

This study contributes to the body of literature dealing with organizational self-awareness, that is, the idea that firms should know and understand their own resources and competences to attain sustained competitive advantages (Denrell et al., 2004; Eggers & Kaplan, 2013; Foss & Foss, 2008; Marino, 1996; Penrose, 1959; Rulke et al., 2000; Schreyögg & Kliesch-Eberl, 2007). Specifically, I address the need identified by Danneels (2011) to study executives' cognition about firms' key resources, as these individuals play the central role in resource management and strategic decision-making. To further advance the concept of managerial resource cognition and to facilitate its operationalization, I conceptualize resource cognition as a construct consisting of two distinct, but complementary components. I propose to distinguish between technology- and market-related resource cognition, as these two resource types represent important assets on which firms rely for strategic change and firm renewal (Danneels, 2002; Mitchell, 1992). Based on a thorough scale development approach, I complement prior empirical studies measuring resource understanding and evaluation (Denrell et al., 2004; Rulke et al., 2000). I provide appropriate scales that enable capturing the extent to which top managers can identify the firm's technology and market-related resources and understand their potential applications in alternative tasks.

The present paper further establishes the relevance and our understanding of managerial judgment about the use of firm resources (Penrose, 1959). As the measurement of resource cognition is based on the responding top managers' subjective perceptions of how well they and other top managers know the resources, naturally, their ratings only reflect what top managers think their firms can do. In Penrose's (1959: 41) words, their ratings correspond to the "subjective productive opportunity" set of the firm, referring to expectations of potential resource applications as opposite to the "objective productive opportunity" set, that is, what the firm is in fact able to do. However, as Penrose argued, if managerial decision-making and resulting firm behavior is to succeed, there must be a relationship between managers' expectations and objective facts.

In this regard, the empirical findings of the study show that, after controlling for several other potential influences, variance in the subjective measurement of resource cognition explains some of the variance in firm success in terms of firm growth. Thus, we can assume that, at least to some degree, the expectations of managers are not too far away from the objective possibilities and a high extent of managerial resource cognition might be a good basis for sound judgments regarding successful future paths. Moreover, the study's results indicate that the effectiveness of top managers' resource cognition is further improved in a decentralized organization. This is because the information top managers access is of higher quality and quantity, as they can more easily draw on diverse expertise from throughout the firm, often from those locations that are closer to the actual issues. Accordingly, this reasoning may suggest that more objectivity is added to managerial judgment through a decentralized structure.

Dynamic Managerial Capabilities

The present analysis increases our understanding of the underlying mechanisms of resource orchestration and transformation at the top management level (Kor & Mesko, 2013; Teece, 2012) and thereby extends prior research into dynamic managerial capabilities in several ways (Adner & Helfat, 2003; Beck & Wiersema, 2013; Martin, 2011; Sirmon & Hitt, 2009). First, this study identifies *what* specific cognitive type of dynamic managerial capabilities may affect firm performance – a research issue which is still relatively under-researched (Eggers & Kaplan, 2013; Helfat & Peteraf, 2015). The paper deepens the conceptualization of resource cognition as a dynamic managerial capability by characterizing it as a cognitive activity to engage in a subjective, creative imagination of alternative uses of resources with the intention to influence firm outcomes. Resource cognition is further described as a non-routine, but patterned act which can be used in a repeatable manner and does not equate to ad-hoc problem solving (cf. Augier & Teece, 2009; Martin, 2011). By conducting the empirical analyses in a highly dynamic industry context, my study addresses the suggestion of recent dynamic capabilities work to track the relationship between resource cognition and firm performance under conditions of change (Helfat & Martin, 2015). Specifically, by proving the effectiveness of this managerial capability in terms of firm growth, the results provide empirical evidence that resource cognition may be an important determinant to a firm's evolutionary fitness (Helfat et al., 2007).

Second, this paper shows *how* managerial resource cognition as a dynamic managerial capability consisting of distinct components affects firm performance (Sirmon & Hitt, 2009). The

data underscore that the components of technology- and market-related resource cognition have complementary performance effects. A comparison between the results from the main and post-hoc analyses highlights that the combination of the two components of resource cognition – either as an additive or a multiplicative index – is positively related to firm growth, whereas when the two components are treated as separate predictors, they only affect growth in patches and none of them exhibits significant effects across all models considered in the analyses. Thus, thinking about the potential attributes of one resource type may often require knowledge about how the other type can be adjusted to gain value. For instance, when top managers have identified an alternative product application for an existing technology, they often need to understand how to adapt marketing resources to successfully commercialize the product. These findings are in line with previous capabilities-based research proposing that firms achieve the highest benefits when leveraging technology- and market-related resources through their synergies (Danneels, 2002; Song et al., 2005).

Third, the present study examines *when* managerial resource cognition is more effective by exploring the contingent role of decentralization and TMT size as important structural elements for the performance effects of this managerial capability. In doing so, I respond to recent calls to investigate the organizational contexts in which dynamic managerial capabilities may lead to superior firm performance (Helfat & Martin, 2015; Helfat & Peteraf, 2015). Concerning the role of decentralization, the empirical analyses revealed that decentralization positively moderates the impact of resource cognition on firm growth. This finding suggests that the quality of managerial decision-making regarding the orchestration of firm resources is improved in a more decentralized organization. Such a structure may prevent the top management from becoming isolated from current developments and lower-level expertise and diminish the problem of information decay when information is communicated upwards through hierarchical levels. More generally, this finding substantiates existing propositions in the dynamic capabilities view that more organic, decentralized organizational structures are conducive to the exercise of dynamic capabilities (Rindova & Kotha, 2001; Teece, 2000, 2007; Wilden et al., 2013).

With regard to the role of TMT size, interestingly and contrary to my expectations, an increase in TMT size may not further improve the positive influence of decentralization on the effectiveness of resource cognition. On the contrary, those firms with smaller TMTs exhibit the highest growth. This rather counterintuitive finding might be explained with insights gained from previous upper echelons and entrepreneurship studies on the disadvantages of large TMTs and

participative strategic decision-making. As the number of team members increases, TMTs are more prone to build factions and have coordination and communication problems, thus making consensus seeking on critical decisions more difficult (Amason & Sapienza, 1997; Boeker, 1997; Halebian & Finkelstein, 1993). Confirming these arguments, TMT size has been found to negatively affect the integrative and collaborative behavior among TMT members (Simsek et al., 2005; Smith et al., 1994) and to increase the likelihood of affective conflicts (Amason & Sapienza, 1997). In a similar vein, prior entrepreneurship research has highlighted that requiring many people to agree upon entrepreneurial strategies impedes the performance effects of a firm's entrepreneurial orientation (Covin et al., 2006). The involvement of many strategic decision-makers may slow down the decision speed and a firm may miss growth opportunities because certain market windows can close while decision-makers struggle to reach a common decision (Covin et al., 2006). In addition, as it is usually much more difficult to secure broad agreement on risky projects (Hamel & Prahalad, 1991), such a high participation in strategic decision-making may weaken the decision boldness in pursuing more radical innovation options, thus limiting a firm's growth potential (cf. McGrath, 1999).

For the unexpected finding of the present study, this reasoning implies the following. With having highly skilled top managers in terms of resource cognition operating in a decentralized organization, the decision-making quality regarding the management of resources seems to be already high enough and a larger TMT will not further improve the situation. Rather, it may impede the decision speed and boldness. However, especially in a dynamic environment and under conditions of continuous change, such as the industry context of this study, the need to address new growth opportunities in a timely manner is high. With fewer members on the team, top managers can react to strategic opportunities for the firm resources more quickly because they do not have to harmonize their considerations with a wide range of people. A smaller TMT can be more decisive in choosing resource transformation projects that are riskier but have higher growth potential and allocating appropriate means to implement those projects. Similar empirical results from Boeker's (1997) study on executive migration and product-market entry further support my finding by providing evidence that smaller TMTs show a stronger association between specific top manager behaviors and strategic change. Future studies can use my finding and similar insights regarding TMT size as a starting point to explore the influence of other and more fine-grained TMT structural elements (e.g., tenure, diversity) on the effectiveness of dynamic managerial capabilities.

Microfoundations and Organizational Context

This paper contributes to the ongoing discussion on microfoundations in strategy and organization theory (Felin et al., 2015). The theoretical explanation proposed in this study corresponds to the “microfoundations as levels” argument (Felin et al., 2015: 586) because managerial resource cognition might be seen as a potential predictor of a phenomenon (i.e., firm growth) that is located at the managerial level and, thus, below the level of analysis of the phenomenon to be explained (i.e., at the firm level). The present paper also underscores the importance of a firm’s top management as a specific group of individuals highly influential in shaping the future strategic directions of the firm that may act as the firm’s information-processing center. In concentrating on the whole group of these individuals rather on single members (e.g., the CEO), this paper further contributes to Eisenhardt’s et al. (2010) understanding of groups as microfoundations of firm performance and it is in line with viewing research on top management attributes as microfoundational (Kemper, Schilke, & Brettel, 2013). Specifically, the study addresses Gavetti’s (2005) call for more work on managerial cognition as a microfoundational element supporting capabilities reasoning (cf. Felin et al., 2015).

Moreover, in this study, I address the role of organizational design in the microfoundations of competitive advantage (Barney & Felin, 2013; Felin et al., 2012). The interplay of top managers’ cognition with decentralization and TMT size underlines the idea that microfoundational explanations should not deny structural elements (Barney & Felin, 2013). Rather, these elements determine with whom top managers interact, how well and what information they access, and how effectively they can make decisions. In doing so, the structural context influences the process of how managerial-level resource cognition is transformed into firm-level growth. Thus, studying these organizational contingencies might increase our understanding of the emergence of higher level phenomena from lower level causes (Felin et al., 2015). Consistent with Helfat and Peteraf (2015), it might be not enough to concentrate the analysis of managerial capabilities on only the actors themselves; it might be equally important to investigate the organizational context these actors face, as even the most skilled top managers may not be able to contribute to the success of a firm if the context hinders them from doing so. Without consideration of contextual effects, we might draw erroneous conclusions about the impact of certain micro-level abilities and only understand half of the microfoundational picture.

Limitations and Future Research

The present paper and its findings should be viewed against the backdrop of its limitation, which may provide starting points for further research endeavors. First, due to the cross-sectional design of the study, I am not able to make strong causal claims. Although I have controlled for several other potential effects, and, thus, attempted to strengthen the theoretical predictions, I cannot (fully) rule out endogeneity issues. Future studies can aim at setting up a temporal sequence of the independent variables to the dependent variable so that resource cognition precedes firm growth over time. Such a setting as well as the adoption of experimental or purely longitudinal designs would improve causal inferences. To better address endogeneity issues, future studies can collect appropriate instrument variables, for instance, measures that capture the experience of top managers with particular resources, using two-stage least squares regressions (Antonakis et al., 2010).

Second, although directly linking resource cognition to firm growth may represent an appropriate way to measure the effectiveness of a dynamic managerial capability (Helfat & Martin, 2015), my empirical approach is not able to trace completely the causal chain suggested in the hypotheses development. Future work can investigate how resource cognition leads to firm growth in a more fine-grained manner by considering mediating variables that reflect top management decision-making and subsequent firm behaviors associated with strategic change such as entry into a new market or introduction of a product innovation.

Third, as a general limitation, survey research is vulnerable to measurement error (Billiet & Matuso, 2012). In particular, the measure for firm growth, since it is subjective, is not beyond being affected by such error, though I undertook several steps to corroborate the accuracy of that measure (e.g., establishing sufficient interrater reliability). Recognizing that objective performance data from privately held firms are difficult to obtain (Dess & Robinson, 1984), future work can conduct a similar study among exclusively public firms to include accounting information gathered from secondary sources and to further increase the reliability of the performance effects. Similarly, realizing that the measurement of cognition through a survey instrument is somewhat limited, future research can cross-validate the newly developed scales in this study for the components of resource cognition with demographic measures such as top managers' educational background. Moreover, additional research is needed to further validate these scales with an independent sample and to augment their generalizability (Hinkin, 1998).

Fourth, the selection of the German medical technology industry as a research setting was guided by the research question and the industry's inherently dynamic environmental conditions. However, such a single industry focus may limit the generalizability of the study's results. Therefore, future studies can explore the performance consequences of managerial resource cognition in a multi-industry setting with an international scope. Also, it would be interesting to conduct a similar investigation among highly diversified firms that are active in several industries. Future work can investigate whether the effects of resource cognition are stronger in such firms and what (perhaps more sophisticated) organizational design elements are required to keep the top management informed about developments in the various areas in which these firms operate.

Finally, progress in understanding resource cognition has been hampered by a lack of clarity regarding the term resources. Therefore, the present paper has specified the types of resources toward which managerial cognition is geared in terms of their technology- and market-related nature. However, the proposed conceptualization may only provide part of the whole picture and could be further disaggregated. For instance, single well-defined resources such as machines might be more obvious for managers to identify and understand than complex resources in the sense of capabilities assembled by several, complementary routines. Both represent so-called resources in the resource-based view and are often used interchangeably (Danneels, 2002), but may indicate different degrees of complexity. While the cognition toward a well-defined resource might be easier to explain, as much of this may be a matter of education, cognition toward a complex capability is more difficult to scrutinize because such a resource may only exist as managers interpret it (Eggers & Kaplan, 2013).

Future work can further advance the conceptualization of managerial resource cognition by differentiating between degrees of resource complexity and by establishing more conceptual clarity regarding resources and capabilities. With regard to capabilities in particular, future studies can reveal how managers come to understand them, that is, what their constituent parts are and how these are assembled (cf. Eggers & Kaplan, 2013). Prior work on the antecedents of organizational self-knowledge by Rulke et al. (2000) provides a good starting point for further research into the determinants of managerial resource cognition. Moreover, I have concentrated on resource cognition of individuals at the top of the firm, which was justified by the assumption that major decisions on adapting, transforming, and recombining the resource base are basically made at this level. However, resource cognition may be located at any level in the firm because

every employee who uses firm resources can engage in resource cognition. Accordingly, future studies may offer further theoretical and empirical insights into the antecedents and consequences of resource cognition, not only at the top management level but also at other levels in the firm.

Appendix 4: Measurement Scales for Control Variables

The following items were included in questionnaire 1 for the first informants (i.e. top and senior managers). These informants were asked to refer their answers to the whole organization.

Formalization (adapted from Jansen et al., 2006)

- (1) For every situation in our firm, written procedures are available for dealing with it.
- (2) Rules and procedures occupy a central place in our firm.
- (3) Written job descriptions exist for all positions in our firm.
- (4) Every employee's performance is recorded in writing.

Integration mechanisms (adapted from Zahra and Nielsen, 2002)

Formal integration

- (1) The activities of the different departments are tightly coordinated.
- (2) The activities of the production and marketing/sales units are tightly coordinated.
- (3) The activities of the R&D and marketing/sales units are tightly coordinated.
- (4) The activities of the R&D and production units are tightly coordinated.

Informal integration

- (1) Our firm maintains open communication channels in its operations
- (2) Our firm stresses informal relationships for realizing things.
- (3) Our firm encourages free exchange of information.
- (4) Our firm encourages informal communication, as needed.

Environmental dynamism (adapted from Jansen et al., 2006)

- (1) In our market, changes are taking place continuously.
- (2) Our customers regularly ask for new products and services.
- (3) Changes in our market environment are often intense.

The following items were included in questionnaire 2 for the second informants (i.e. core knowledge workers). These informants were asked to refer their answers to those employees who are critical to knowledge creation and innovation (i.e. all knowledge workers).

Technical expertise (based on Wiklund and Shepherd, 2003; Matusik and Heeley, 2005)

- (1) Our employees possess excellent technical expertise.
- (2) Our employees have necessary skills to complete difficult technical tasks.
- (3) The technical competences of our employees are very good.
- (4) Our employees hold outstanding expertise regarding the development of technological products.

Market expertise (based on Wiklund and Shepherd, 2003; Shane, 2000)

- (1) Our employees have excellent expertise in marketing.
- (2) Our employees know very precisely how our markets operate.
- (3) Our employees are capable of marketing our products.
- (4) Our employees have profound knowledge about the problems of our customers.
- (5) Our employees possess comprehensive knowledge about how to serve our markets.

Chapter 5

Conclusion

5.1 SUMMARY

The purpose of this dissertation was to contribute to a better understanding of the capabilities that enable firms to strategically adapt to environmental changes and maintain competitiveness over time – referred to as dynamic capabilities. The dissertation followed the conception and classification of dynamic capabilities proposed by Teece (2007); it focused on specific capabilities related to *sensing* and *seizing* business and technological opportunities and to *reconfiguring* organizational resources and structures.

As outlined in the introduction (Chapter 1), the dynamic capabilities view has emerged as a popular and practically relevant field of study over the last decades, but it has also been criticized for its conceptual confusion and underexplored issues. Still too little is known about what these capabilities are and how they can be built and managed. A main concern arises from the fact that most extant research has largely neglected the complexity of social behaviors inherent in capabilities and, thus, has not sufficiently addressed the multilevel aspects, especially the micro-foundations of such capabilities. Against this backdrop, I stated three overall research questions in the introductory chapter which synthesized essential critiques of the capabilities approach and served as an overarching guide for this dissertation. These research questions embraced (1) the nature and locus, (2) the micro-foundations, and (3) the management of dynamic capabilities.

The dissertation aimed at addressing these questions with three distinct and self-contained research papers which deal with specific capabilities related to one or more of the capability types of sensing, seizing, and reconfiguring. The first paper (Chapter 2) offers a systematic review of the innovation literature and reinterprets evidence from prior empirical studies through the dynamic capabilities lens; it uncovers multilevel antecedents and consequences of sensing-, seizing-, and reconfiguring-related activities in innovation and develops propositions for future research. The second paper (Chapter 3) is an empirical study on the origins of a firm's absorptive

capacity which corresponds to the sensing and seizing capability types; it explores how organizational integration mechanisms, through their impact on knowledge workers, influence a firm's ability to absorb and leverage new knowledge and reveals the cognitive process of perspective-taking and creative behavior as important micro-foundations. The third paper (Chapter 4) is an empirical study of the concept of resource cognition, which is conceptualized as a managerial capability underlying reconfiguring; it further develops the concept in terms of top managers' cognition about the firm's technology- and market-related resources and empirically examines performance implications and the contingent roles of decentralization and top management team size.

5.2 OVERALL IMPLICATIONS

In the following section, I discuss the dissertation's implications by pointing out how the findings of the three research papers help to answer the overall research questions that motivated this dissertation. Naturally, as these questions were rather broadly defined, the findings cannot fully answer them, but they further advance what we know about dynamic capabilities. Table 5.1 outlines the main implications that each paper provides regarding the three overall research questions.

Nature and Locus of Dynamic Capabilities

The first overall research question asked what dynamic capabilities are and where they are located. This question pointed to the debate in the literature regarding the nature of dynamic capabilities, which reflects basically two views (cf. Barreto, 2010; Di Stefano et al., 2014; Peteraf et al., 2013). One view regards dynamic capabilities as latent abilities, being rather indirectly observable once they are called into action (e.g., Teece et al., 1997; Winter 2003; Zahra & George 2002), whereas the other defines dynamic capabilities in terms of concrete, more directly observable processes and routines (e.g., Eisenhardt & Martin, 2000; Schilke 2014; Zollo & Winter, 2002). Moreover, different conceptualizations exist with respect to whether these capabilities are situated at the organizational level only (e.g., Teece et al., 1997; Zahra & George, 2002) or at lower levels of analysis (e.g., Helfat & Peteraf, 2015; Zahra et al., 2006).

Table 5.1: Main Contributions to the Overall Research Questions (ORQ)

	Paper 1 <i>Dynamic Capabilities in Innovation</i>	Paper 2 <i>Origins of Firm-Level Absorptive Capacity</i>	Paper 3 <i>Resource Cognition as a Managerial Capability</i>
ORQ 1: <i>Nature and Locus of Dynamic Capabilities?</i>	<ul style="list-style-type: none"> • Revealed concrete, clearly identifiable innovation activities, processes, and routines which are related to sensing, seizing, and reconfiguring capabilities and predominantly conceptualized at the organizational level. • Identified the need for future research to offer conceptualizations in terms of acting micro-level entities. 	<ul style="list-style-type: none"> • Absorptive capacity treated as a latent capability at the organizational level. • <u>Emerging research strategy I</u>: If capability is understood and conceptualized as latent, organization-level explanandum, then need to explore concrete, observable explanans / explanantia. 	<ul style="list-style-type: none"> • Resource cognition conceptualized as a more concrete cognitive capability at the managerial level. • <u>Emerging research strategy II</u>: If capability is used as explanans for firm-level explanandum (e.g., firm performance or other firm-level capability), then need to exclude any tautology and conceptualize the capability in terms of acting micro-level entities.
ORQ 2: <i>Micro-Foundations of Dynamic Capabilities?</i>	<ul style="list-style-type: none"> • Unveiled insights from extant innovation research into micro-level factors of capabilities-related activities. 	<ul style="list-style-type: none"> • Emphasized the critical role of knowledge workers. • Revealed and examined the influence of cognitive and behavioral micro-foundations. 	<ul style="list-style-type: none"> • Underscored the important role of top managers. • Regarded resource cognition as micro-foundational for firm-level competitive advantage.
ORQ 3: <i>Management of Dynamic Capabilities?</i>	<ul style="list-style-type: none"> • Proposed a multilevel moderated mediation model of capability formation. • Suggested considering organizational contingencies in addition to environmental contingencies when managing the effectiveness of capabilities. 	<ul style="list-style-type: none"> • Provided evidence of formal and informal organizational mechanisms to directly induce individuals' condition and action conducive to capability building. • <u>Managerial implication</u>: Active management of firm capabilities through establishing the right organizational conditions and/or hiring individuals with the required traits. 	<ul style="list-style-type: none"> • Provided evidence of firm internal structural elements fostering or impeding a managerial capability's performance. • <u>Managerial implication</u>: Leveraging managerial cognitive capabilities by providing a broader organizational context that ensures managers' access to high-quality information and by optimizing the closer context in which managerial decisions are eventually made.

The dissertation enriches this debate in several ways. The first research paper supported the view regarding dynamic capabilities as concrete processes and routines by reviewing extant innovation research and revealing specific and clearly identifiable innovation activities associated with sensing, seizing, and reconfiguring. These activities were predominantly conceptualized at the organizational level, but, apart from some exceptions, previous innovation studies have not paid sufficient attention to who actually performs these activities and how. Thus, the paper identified the need to offer more conceptualizations which consider the actual acting micro-level entities such as top managers, key R&D employees, and product development project teams. This need was stressed to be particularly high when conceptualizing reconfiguring-related activities because these activities are inherently more difficult to routinize as organizational processes and highly depend on entrepreneurial judgment and behavior at the micro level (cf. Teece, 2012).

The empirical studies in this dissertation – the second and third research papers – followed different kinds of conceptualizations. The second paper treated absorptive capacity as a rather latent ability at the organizational level. It measured this capability as a four-dimensional construct with scales originally developed in previous research but adapted to the study's empirical setting. These scales capture how well a firm is able to acquire, assimilate, transform, and exploit new knowledge by asking appropriate questions. However, these scales do not describe very specific firm-level processes or routines; at the utmost, they reflect firm processes only superficially or mirror rather outcomes of actions. In contrast, the third paper conceptualized managerial resource cognition as a more concrete cognitive capability at the managerial level underlying the orchestration and reconfiguration of a firm's resources. It operationalized this capability directly at the micro level by developing scales that were specified for a certain group of individuals within the firm (i.e., top managers) and gauged these individuals' specific cognition toward two important types of corporate resources. Thereby, the study strengthened the idea of defining capabilities themselves in terms of those individuals who actually act – as suggested in the first research paper.

Taking the findings of each research paper together, the dissertation may not perfectly reconcile the debate regarding the right conceptualization of the nature and locus of dynamic capabilities. Rather, the dissertation's results imply two different, emerging research strategies for future studies on dynamic capabilities and capabilities-related activities. I call these strategies emerging research strategy I and II, according to whether the capability construct is used as an

explanandum (i.e., as the phenomenon to be explained) or explanans (i.e., as an explanatory factor of a phenomenon).

Emerging research strategy I proposes that if a capability is understood and conceptualized as a latent, organization-level explanandum, then appropriate research needs to explore its observable, concrete explanans or explanantia at the micro and macro levels. Indeed, it can be helpful to define a dynamic capability as a latent, organizational ability to attain a greater degree of abstraction and generalizability (Peteraf et al., 2013; Teece et al., 1997). However, when following this kind of conceptualization, we must also acknowledge the highly endogenous character of a latent ability. In line with Felin and Foss (2009), we then need a clear and profound understanding of the manifest origin(s) of the latent firm ability. Otherwise, the phenomenon of such capability will remain fuzzy and ambiguous and risks eventually becoming insubstantial or even meaningless – like an anonymous assertion whose trustworthiness we doubt because we do not know its source(s).

Emerging research strategy II proposes that if a capability is used as a direct explanans for an organization-level explanandum, appropriate research should conceptualize the capability in a concrete and identifiable manner at levels lower than the organizational level (i.e., in terms of those micro-level entities that actually act in a clearly defined capability or capability-related activity). By including specific organization members or a specific group of organization members in the capability construct, the conceptualization is less prone to fuzziness and ambiguity. When the organization-level explanandum is a firm-level outcome (e.g., firm performance, innovativeness, adaptability to environmental changes), these conceptualizations should also exclude any tautology and clearly separate the capability construct from the outcome (cf. Helfat & Martin, 2015).¹⁸ Furthermore, the conception of a micro-level capability suggested here can also be used as an explanans for another, but organization-level, perhaps latent capability (as the explanandum). In previous work, the idea that one dynamic capability (e.g., reconfiguring) may determine another one (e.g., sensing or seizing) has been compiled with a hierarchical ordering (Collis, 1994; Helfat & Peteraf, 2003; Peteraf et al., 2013; Winter, 2003): A dynamic capability that can change or adapt another dynamic capability may be understood as a higher order, organizational dynamic capability.

¹⁸ That is, firm performance should not be part of the definition and operationalization itself, for example, in the sense of a micro-level dynamic capability aimed at making a firm perform better than others, or in terms of a capability's broader, ultimate purpose, such as aiming "to address rapidly changing environments" (as used in the original definition by Teece et al., 1997: 516; see also Barreto (2010) for a similar argument).

However, two major problems arise regarding this notion. First, a higher order dynamic capability implies a higher degree of abstraction on a meta-level (Salvato & Rerup, 2011), making the construct more difficult to operationalize, not to mention measure. Second, such a higher order dynamic capability must satisfy higher needs for dynamization and flexibility (cf. Schreyögg & Kliesch-Eberl, 2007). On the other hand, this overstretches or even contradicts the “proper” conception of an organization-level capability, which must exhibit a certain extent of routinization and stability to be considered an organizational capability (Schreyögg & Kliesch-Eberl, 2007). In contrast, the conception of a micro-level or managerial-level dynamic capability may help to overcome these problems. It makes the capability construct easier to operationalize and measure because it is coupled with specific actors in a firm. It is also better suited to reflect the entrepreneurial judgment and more non-routine behavior inherent in a capability that is intended to be more flexible and dynamic so as to change and adapt other dynamic capabilities.¹⁹

Micro-foundations of Dynamic Capabilities

The second overall research question asked where dynamic capabilities originate. This question pointed to calls to examine the micro-foundations of dynamic capabilities (Abell et al., 2008; Felin & Foss, 2005; Felin et al., 2012; Gavetti, 2005). While the central dynamic capabilities literature has mainly highlighted the importance of dynamic capabilities for firm-level performance (e.g., Helfat et al., 2007), research has to a lesser extent empirically explored the antecedents of these capabilities (cf. Felin & Foss, 2009; Kemper et al., 2013); those studies that have dealt with antecedents have largely focused on the organizational level only (e.g., Danneels, 2008; Jansen et al., 2005). However, work, notably of the empirical kind, on the micro-level foundations of dynamic capabilities is relatively scarce; we still have a limited understanding of how these capabilities emerge from levels lower than the firm level, especially from the characteristics, actions, and interactions of firms’ individual members (Barney & Felin, 2013; Felin et al., 2015; Foss, 2009).

The dissertation’s single papers addressed the calls for more research into the micro-foundations in various ways. The first research paper provided preliminary insights from innovation research into micro-level factors that potentially influence dynamic capabilities. It revealed that the cognitions, personal networks, abilities, and expertise of individuals in the firm

¹⁹ In a similar line of thought, Di Stefano and colleagues (2014) proposed a model of dynamic capabilities in which individual-level or managerial capability-related actions are considered antecedent to organization-level, more complex routines.

are associated with activities related to sensing, seizing, and reconfiguring. Also, by analyzing team-level innovation studies, the paper unveiled some conditions, such as team autonomy, project skills, and shared mental models, which may be antecedent to dynamic capabilities. Although useful as a first indication of where to look in searching for potential micro-foundations, most of these prior studies were single-level and did not explicitly link the lower level factors to higher level, firm-level, capabilities-related activities and outcomes.

The second research paper, however, explicitly took a cross-level approach. It disaggregated the analysis to the level of those employees who might be most critical for development of the organizational capability in question. In this particular case, the paper emphasized the critical role of knowledge workers and explored how their motivated cognition and creative behavior affect the firm's absorptive capacity. By using data gathered at the firm level as well as at the level of knowledge workers and by employing a statistical method that allows for testing micro-level effects on macro-level outcomes, the paper showed that heterogeneity among firms' key employees regarding their characteristics account for differences between firms in their organizational dynamic capabilities. The third research paper focused the analysis on those individuals who are most relevant for a firm's strategic resource orchestration, that is, a firm's top managers. In contrast to the second paper, where I studied the micro-foundations of a latent firm capability, the third paper treated top managers' resource cognition as a micro-level dynamic capability itself; by indicating how resource cognition affects firm growth, the paper regarded this managerial capability as micro-foundational for a firm's competitive advantage.

All in all, the dissertation has put individuals more strongly at the heart of dynamic capabilities reasoning by highlighting the importance of key organization members. It has theoretically identified and empirically investigated what and how characteristics at the micro level matter to the development and understanding of dynamic capabilities. Furthermore, the dissertation has suggested and actually applied a multilevel design and method that enables scholars to tackle the empirical challenges that surround micro-foundational work more generally in a large N context (cf. Felin et al., 2015). Future empirical work on the micro-foundations of dynamic capabilities may use a similar approach to further advance our understanding of where these capabilities originate.

Management of Dynamic Capabilities

The third overall research question asked how dynamic capabilities are formed and how their effectiveness can be fostered by firms. This question pointed to the management of dynamic capabilities' formation and performance. In addition to the deficiency in knowledge on micro-foundations, the question arises regarding the specific organizational conditions firms can set in place to actively build dynamic capability (Eggers & Kaplan, 2013; Rothaermel & Hess, 2007). Concerning the consequences of dynamic capabilities, as argued in previous work, their mere possession does not guarantee success (Beck & Wiersema, 2013; Helfat et al., 2007). Therefore, we need to understand how the context in which dynamic capabilities operate affects the link between capabilities and firm performance (Barreto, 2010; Helfat & Martin, 2015; Helfat & Peteraf, 2015). In other words, what organizational conditions can firms provide to enable or strengthen the effectiveness of their dynamic capabilities and what detrimental conditions which may hinder firms in materializing their capabilities into competitive advantages should firms avoid or remove?

The individual papers of the dissertation addressed these open issues with different emphases. The first research paper revealed specific organizational antecedents of dynamic capabilities-related innovation activities (e.g., specific organizational structures, physical resources, culture). The paper proposed to reinterpret these antecedents as potential intervening and context factors to manage the building and performance of capabilities. More specifically, it introduced a multilevel moderated mediation model of capability formation. In this model, relationships between organizational antecedents and firm capabilities are proposed to be mediated by team-level as well as individual-level attributes; specific context factors (e.g., team goals, coordination mechanisms) were suggested with respect to influencing and shaping the interrelations between lower and higher levels. Thus, the model underscored that firms should consider interdependencies across different levels in the organization when building dynamic capabilities. Moreover, the paper highlighted the need to account for organizational contingencies (e.g., organization design elements) in addition to environmental contingencies (e.g., environmental dynamism) when managing the effectiveness of capabilities because firms may be more easily and directly able to design and change their internal versus their external environment.

The empirical studies then provided corroboration for the management of specific capabilities. While the second research paper showed how firms' manage to build a firm

capability, the third research paper indicated how firms' manage to foster the effectiveness of a managerial capability. More specifically, the second paper demonstrated evidence of formal and informal integration mechanisms at the organizational level to induce (at least to some degree) knowledge workers' condition and behavior conducive to form a firm's absorptive capacity. Thus, as a more general managerial implication, the findings imply that firms may not directly act upon latent abilities, such as absorptive capacity, themselves. Rather, they may more indirectly influence and build such capabilities by establishing certain organizational conditions proven to favor certain actions among employees (cf. Foss, 2011).

The third research paper provided evidence of the combined effects of different organization design elements (i.e., organizational structure and TMT structure) on the managerial capability-performance link. To leverage the effectiveness of managerial resource cognition, the findings imply that firms should provide a context in which the availability of high-quality information for managerial decision-making is ensured, for example, through maintaining a high degree of organization-wide decentralization. At the same time, firms should optimize the closer context in which managerial decisions are eventually made, for example, by keeping the size of the TMT small enough to avoid the high costs of consensus seeking among top managers, thereby enabling fast and bold decision-making. Thus, the general managerial implication of the study is that firms must carefully align their dynamic capabilities with not only the broader organizational context but also the closer context in which dynamic capabilities are actually deployed.

Furthermore, besides managing capabilities through certain organizational conditions that can influence existing employees and top managers, both empirical studies also have implications for firms' selection of new employees. In the case of absorptive capacity, firms may hire new employees who are highly capable at taking different perspectives and exhibit a high degree of creativity. Regarding resource cognition, firms' may recruit managers who are proficient in analogical reasoning, that is, applying familiar knowledge to a less or non-familiar area (Ward, 2004). While these attributes may not be easy to identify or articulate, firms may look for persons whose experience and/or education suggest they are likely to possess these attributes. For instance, firms may seek to employ persons who have profound expertise in a specific field and more general knowledge in other related fields (also referred to as T-shaped skills; Madhavan & Grover, 1998). They may also hire individuals who have expertise in more than one area, such as engineers with a master's degree in business administration (also referred to as A-shaped skills; Madhavan & Grover, 1998) or persons with cross-cultural experience who have a broad pool of

knowledge and can align different knowledge domains (Vandor & Franke, 2016). Future research can empirically examine the potential and relevance of these and similar skills and experiences for the formation of dynamic capabilities.

5.3 CONCLUDING REMARKS

The aim of this dissertation was to advance our understanding of the multilevel aspects and micro-foundations of dynamic capabilities by focusing on specific capabilities related to sensing and seizing new business opportunities and to reconfiguring corporate resources. In the form of three independent research papers the dissertation addressed deficits in the literature regarding the nature, origins, and management of dynamic capabilities. On the basis of a thorough analysis of the existing capabilities-related innovation literature, it suggested several research avenues for theory development and testing. The dissertation translated some of these suggestions into concrete hypotheses in the context of specific capabilities and exposed the hypotheses to empirical testing based on unique multi-informant survey data collected in a dynamic industry and supplemented with secondary data sources. While the dissertation empirically explored the multilevel antecedents of an established, well-accepted latent capability, it also examined the performance implications of a newly introduced managerial capability.

Regarding the nature and locus of capabilities, on the one hand, the dissertation's results imply that research should define dynamic capabilities in a concrete manner. The dissertation proposes to include the micro-level entities that actually act in the construct itself, especially when considering capabilities as more direct causes explaining heterogeneity in firm-level performance. On the other hand, the dissertation acknowledges that capabilities can also be conceptualized as latent abilities at the organizational level to attain a higher degree of abstraction. However, in this case, research needs to be very clear about what observable, micro- and macro-level antecedents cause the latent firm capability and explain the intra- and inter-level causal mechanisms.

Regardless of whether conceptualizing a capability as a latent organizational ability or a concrete managerial capability, the dissertation has put individuals at the center stage of dynamic capabilities reasoning. Moreover, it has shown how organizational conditions, through their influences on and interactions with key organization members, matter to the management of capabilities. To further advance micro-foundational explanations of capabilities, future research can further and more deeply examine the emergence mechanisms of capabilities from the micro

level. Specifically, future work can empirically investigate what and how firm internal as well as firm external context factors moderate the bottom-up effects from individuals' behaviors to team-level activities and then from team-level activities to organization-level capabilities. The multilevel moderated mediation model of capability formation proposed in the dissertation's first research paper may serve as a helpful starting point for such research endeavors. In sum, the dissertation developed new insights into the building and efficacy of dynamic capabilities. Thus, the dissertation opened – some more – the black box of what enables firms to strategically adapt to changing environments and may inspire other scholars to further explore the micro-foundations, organizational conditions, and performance implications of dynamic capabilities.

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