Open Innovation and Organizational Alignment
A contingency analysis of external search strategies for innovation performance

Von der Fakultät für Wirtschaftswissenschaften der
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<td>α</td>
<td>Alpha (Cronbach’s Alpha)</td>
</tr>
<tr>
<td>CIS</td>
<td>Community Innovation Survey</td>
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<tr>
<td>DFG</td>
<td>Deutsche Forschungsgemeinschaft</td>
</tr>
<tr>
<td>Eds.</td>
<td>Editors</td>
</tr>
<tr>
<td>e.g.</td>
<td>Exempli gratia (for example)</td>
</tr>
<tr>
<td>et al.</td>
<td>Et alii (and others)</td>
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<tr>
<td>H</td>
<td>Hypothesis</td>
</tr>
<tr>
<td>i.e.</td>
<td>Id est (that is)</td>
</tr>
<tr>
<td>NIH</td>
<td>Not Invented Here</td>
</tr>
<tr>
<td>n.s.</td>
<td>Not significant</td>
</tr>
<tr>
<td>OECD</td>
<td>Organization for Economic Cooperation and Development</td>
</tr>
<tr>
<td>OLS</td>
<td>Ordinary Least Squared</td>
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<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>RWTH</td>
<td>Rheinisch-Westfälische Technische Hochschule (RWTH Aachen University)</td>
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<tr>
<td>S.D.</td>
<td>Standard Deviation</td>
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1 Introduction

1.1 Background and objectives of this research

The continuous generation of innovation is one of the major endeavors that firms have to accomplish (Drucker, 1985). Traditionally, this has been regarded as being solely in the realm of firms’ internal activities, such as research & development or new product development. Yet, knowledge and innovative ideas are widespread and abundantly available in firms’ environment (Chesbrough, 2003a). Enabled by advances in technology, these ideas may find a way to implementation other than the usual firm-centered ones and a new perspective may be needed, therefore (Chesbrough, 2003a). In this regard, Henry Chesbrough (2003a) coined the term "open innovation" to acknowledge that in order to increase innovation performance, firms’ need to make use of external knowledge more systematically or “purposively” (Chesbrough, 2006a:1). The concept of open innovation suggests that firms make use of knowledge available in the external environment of their organization and combine knowledge developed inside the firm with knowledge generated through external search efforts (Almirall and Casadesus-Masanell, 2010; Lichtenthaler and Lichtenthaler, 2009).

Open innovation processes have become an increasingly important issue of research, as recent reviews around open innovation indicate (Dahlander and Gann, 2010; Huizingh, 2011; Lichtenthaler, 2011; Trott and Hartmann, 2009; Van de Vrande et al., 2010). At the same time, also management practice has adopted open innovation (Chesbrough, 2006a; Dodgson et al., 2006; Huston and Sakkab, 2006; Rohrbeck et al., 2009). Extant research has shown that firms benefit substantially from external knowledge integration and the utilization of a diverse set of external partners during the innovation process (e.g. Baum et al., 2000; Cassiman and Veugelers, 2006; Faems et al., 2010; Katila and Ahuja, 2002; Laursen and Salter, 2006). But previous research has also suggested that openness has limitations in its positive effects for the increase and improvement of innovation performance.

Openness has been shown to have an inverted U-shaped effect on innovation performance (Deeds and Hill, 1996; Duysters and Lokshin, 2011; Katila and Ahuja, 2002; Knoben and Oerlemans, 2010; Laursen and Salter, 2006; Rothaermel and Deeds, 2006). Rothaermel and Deeds (2006), for example, identify diminishing marginal returns to the level of alliance activity of firms, predicting an inverted U-shaped
relationship between the number of simultaneously managed alliances and firm performance. Similarly, Duysters and Lokshin (2011) find alliance portfolio diversity being curvilinearly related to innovation performance. In a similar vein, but with a more general perspective of firms’ openness, Laursen and Salter (2006) argue that a higher degree of openness, understood as greater diversity (breadth) and intensity (depth) of external search activities is not indefinitely associated with higher innovation performance. Rather, the authors find an inverted U-shaped relationship between external knowledge utilization and innovation performance. Firms improve their innovation performance by searching among a greater amount of external sources, yet this positive effect suffers from diminishing marginal returns with the increase of utilization levels, and even decreases from a certain degree of openness onwards (Laursen and Salter, 2006). In addition, external search breadth and depth impact differently on incremental and radical innovation performance (Laursen and Salter, 2006). Yet, literature provides divergent findings regarding the actual impact relations. Laursen and Salter (2006:144-145) show that radical innovation benefits from deep search relations and incremental innovation performance profits from broad search, whereas Chiang and Hung (2010) constitute the actual opposite.

Apparently, the positive effects of external knowledge for a firm's innovation performance are limited and mixed. These performance limitations mainly arise from the efforts and costs associated with the actual search for external knowledge but also from the subsequent integration efforts (Laursen and Salter, 2006). To fully utilize the potential external knowledge provides, firms also need to absorb and integrate the knowledge they acquire (Cohen and Levinthal, 1990). Thus, successful open innovation hinges on firms’ internal capacities to process acquired knowledge resources (Lichtenthaler, 2011:88). Implementing open innovation seems to pose significant managerial difficulties (Lichtenthaler, 2011:80). Firms may need to develop or implement new practices in order to benefit from open innovation (Dahlander and Gann, 2010; Foss et al., 2011).

The importance of open innovation as a research topic and as a managerial practice is undeniable. In fact, the application of open innovation in firms shows high failure rates (Lichtenthaler and Lichtenthaler, 2009:1316). Albeit the recent “buzz” around open innovation and the opportunity to improve innovation performance by the means of
utilizing external knowledge it is important to understand how firms’ internal organization and practices exactly can facilitate their efforts to draw benefits from open innovation (Brunswicker, 2011; Chesbrough, 2006b). As previous studies suggested that open innovation can also be detrimental to firms’ innovation performance, understanding how the U-shaped relationship between openness and innovation performance can be manipulated or influenced for the benefit of the innovating firm is crucial. Open innovation does not imply that firms are set free of the need to coordinate and structure, but it requires appropriate measures by management to enhance a firm’s ability to process external knowledge internally (Bergman et al., 2009).

Recent research encourages the investigation of the application prerequisites and conditions of open innovation (Laursen and Salter, 2006; Van de Vrande et al., 2010). Hitherto, however, there is only little empirical research in the existing literature on open innovation regarding the performance effects of utilizing external knowledge and the possibilities for companies to align their organizations appropriately. A few case studies have provided evidence of the importance of structures and process design, cultural context, and the implementation of certain technologies or tools for the successful implementation of open innovation (Chesbrough and Crowther, 2006; Dodgson et al., 2006; Sakkab, 2002). Other research has confirmed the effects of external knowledge for innovation performance (Cassiman and Veugelers, 2006; Laursen and Salter, 2006; Leiponen and Helfat, 2010). Yet, large-scale investigations of open innovation, its performance implications, and the appropriate organizational alignment are scarce (Foss et al., 2011; Laursen and Salter, 2006). Our study takes up this deficit and investigates how organizations may align with and support the new mode of innovating.

Adopting a contingency theory perspective, we investigate how firms have to align their organization to their respective openness level and search strategy (i.e. search breadth and depth). Thus, this research aims at extending the existing literature by investigating possible moderators for the relationship between openness and innovation performance. Building on the most salient aspects in contingency-based examinations, this research investigates the alignment of firms’ organizational structure, culture, and innovation strategy with their level of openness (Burton and Obel, 2004; Drazin and Van de Ven, 1985; Miles and Snow, 1978; Mintzberg, 1979). To investigate organizational
alignment our study follows previous research and adopts the concept of “fit”. Building on a fit as moderation perspective (Venkatraman, 1989), we study whether organizational structure, culture, and innovation strategy as contingency factors are in fit, either “horizontal” or “vertical”, with firms’ openness (Burton & Obel, 2004; Doty et al., 1993). These factors of analysis and a call for respective investigations can also be found in recent literature on open innovation (Lichtenthaler, 2011: 85-86; Van de Vrande et al., 2010:228).

Opening up the innovation process is a discretionary activity - a strategic choice - for firms’ innovation management (Brunswicker, 2011). Choices regarding search openness, search intensity, and search directions have to be made (Bahemia and Squire, 2010). In order to better understand open innovation and to advance extant knowledge for theory and managerial practice, it is necessary to understand how firms can make better use of their external search efforts. In sum, this research extends the literature on open innovation and aids managerial practice by addressing the following:

- Investigation of the effects of external knowledge search for innovation performance – confirmation of inverted U-shaped relation?
- Investigation of the effects of external knowledge search for radical and incremental innovation performance – conflicting findings in previous research?
- Investigation of conditions for the facilitation of external knowledge search – implications of organizational structure, culture, and strategy?

### 1.2 Research structure and thesis outline

Commencing with this introduction, the argumentation of the present thesis contains 5 further chapters and is summarized and illustrated in Figure 2.

Following this introduction, Chapter 2 presents the general theoretical background of this research, its motivation, and research questions. In detail, Section 2.1 discusses the understanding of open innovation assumed for this research and its relation to more general theoretical aspects of organizational knowledge search. The effects of external knowledge search on innovation performance are discussed. Section 2.2 presents the findings and approaches discussed in the literature concerning opportunities for the management of open innovation. The need for more thorough analysis is discussed and the theoretical angle employed for this research is presented.
In its central part, this research is divided into four hypotheses-development parts in Chapter 3. Each section deals with one of the four major aspects of this research and is organized and designed in support of a subsequent journal paper preparation. Accordingly, each section starts with a brief introduction and continues with a comprehensive theory review and the respective hypotheses development. The research model underlying this study consists of four related investigations (Figure 1).

![Figure 1: Overview research studies](image)

Firstly, in Study I, the fundamental relation between a firm’s openness and its innovation performance is investigated (Section 3.1). Secondly, in Studies II to IV, the basic relation between openness and innovation performance is amended by a contingency analysis and a moderation-fit analysis of organizational structure, culture, and strategy characteristics (Sections 3.2 to 3.4). The chapter concludes with a summary and an overview of the hypotheses in Section 3.5.

Chapter 4 presents the empirical study employed in this thesis. Section 4.1 presents the data collection process and descriptive characteristics of the sample. The variables of this research and their respective measurements are presented in Section 4.2. Section 4.3 gives a brief overview of the methods employed.
In Chapter 5, the empirical results of this research are presented, following a similar structure and intent like Chapter 3 (preparation of journal paper modules). Section 5.5 summarizes the key results.

Chapter 6 discusses the results of this research. The chapter begins with the discussion of the theoretical implications and contributions of the results in Section 6.1. In Section 6.2 managerial implications are discussed. Section 6.3 presents limitations of this research, possible opportunities for further research, and finalizes this thesis with a short conclusion.

Figure 2: Structure of research and chapter organization
2 Conceptual background, research motivation, and research questions

2.1 Theoretical background and empirical evidence of open innovation and innovation performance

2.1.1 Definition of open innovation and conceptual understanding

The availability of knowledge is one of the most prominent prerequisites for firms’ innovation activities and success (Grant, 1996; Subramaniam and Venkatraman, 2001). In order to generate new knowledge, firms increasingly tap into their external environment and utilize outside knowledge sources (Sofka and Grimpe, 2010). Utilizing external knowledge and combining it with the knowledge resources available inside the organization is said to be beneficial for firms’ innovation performance (Cassiman and Veugelers, 2006).

This involvement of firm-external sources has recently been termed an “open innovation” model as opposed to a “closed innovation” model, which describes how firms traditionally managed their innovation and knowledge generation activities – in-house, relying on their own research and development units (Chesbrough, 2003a; Chesbrough, 2006a). Open innovation describes an approach in which firms involve a wide range – with regard to amount and diversity – of outside actors in their innovation processes in order to leverage or exploit those parties’ knowledge (Chesbrough, 2003a).

The importance of external knowledge for innovation performance, and, in turn, firm performance, has also been suggested in a number of other research fields. For instance, Ahuja (2000) sheds light on the effects of firms’ direct and indirect external relations for their innovation performance. Rosenkopf and Nerkar (2001) show the importance of boundary-spanning activities for technological innovation. Rothaermel (2001) demonstrates how important it is for established firms in the pharmaceutical industry to cooperate with (young) firms in the biotechnology sector, in order to adapt to technological changes. Also the literatures on strategic alliances and new product development recently added to the acceptance of external knowledge as an important driver of firm and innovation performance. Rothaermel and Deeds (2006), for example, find positive effects of firms’ alliances for firm performance. Duysters and Lokshin (2011) find similar effects for firms’ alliance portfolios. The involvement of external parties into the new product development process, ranging from customers over suppliers to research institutes, has been identified to be positive for firms’ innovation
activities and performance (Brown and Eisenhardt, 1995; Dyer, 1996; Li and Calantone, 1998; Urban and Von Hippel, 1988; Van Echelt at al., 2008).

In strategic management, research on dynamic capabilities (Teece et al., 1997), combinative capabilities (Kogut and Zander, 1992), and absorptive capacity (Cohen and Levinthal, 1989, 1990) or organizational adaptability (Van den Bosch et al. 1999) also emphasized the importance of integrating and utilizing external knowledge for the successful long-term development of companies. This is also shown by literature on knowledge transfer. The inter-organizational transfer of knowledge, hence the utilization of external knowledge, was shown here to be of major importance for firms’ (innovation) performance (Day, 1994; Lane et al., 2006; Lyles and Salk, 1996; Powell et al., 1996).

In management practice, the “Connect & Develop” program of Procter&Gamble has become the “poster child” for the move towards open innovation. Known as a fierce competitor and market contester relying strongly on the strength of its in-house research and development capacities, Procter&Gamble today is a best-practice example of the turn towards open innovation. P&G has become an organization aligned to the idea of open innovation. The company has its own program concerned with outside knowledge and idea sourcing, strategy, and goals set to source up to fifty per cent of its innovations from outside and organizational functions dedicated to open innovation alone (Huston and Sakkab, 2006). The implementation of this comprehensive open innovation program is reported to have increased the company’s productivity and innovation performance significantly (Huston and Sakkab, 2006).

**Closed versus open innovation**

As argued before, the traditional view of firms’ endeavors to improve innovation performance was dominated by an in-house focus and an emphasis on firms’ own R&D efforts. Firms spent significant resources to create sufficient R&D capabilities and to exploit the results of these efforts (Chesbrough, 2006a; Teece, 1986). The closed innovation model assumes firms’ innovation success roots in the exertion of strong control over their innovation activities and outcomes, ensuring that the maximum benefit of these activities accrue to the originating firm (Chesbrough, 2003a, 2003b, 2006a; Vanhaverbeke and Cloodt, 2006). Firms following the logic of the closed innovation model assume that the increase of R&D capacity in terms of budget and
human capital, the control over the whole span of the innovation process from idea generation to final sales, and strong IP regimes guarantee high returns and innovation success (Chesbrough, 2003a). In the closed innovation world, firms’ boundaries are systematically kept as impermeable as possible (Figure 3). In the open innovation world, on the other hand, firm boundaries are systematically opened and kept permeable to outside knowledge influx (Figure 3).

![Figure 3: Closed and open innovation model (according to Chesbrough, 2003a)](image)

However, with the changes the conditions in which business is conducted have seen, this model is no longer sustainable (Brunswicker, 2011:37). The increase of labor availability and mobility, the abundance of venture capital, and increased capability levels among external parties, such as suppliers, are among the factors which stirred this development (Chesbrough, 2003a). According to Chesbrough (2006a:1), the open innovation model is defined as:” [...] purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively”. Thus, open innovation is understood as the use of organizations’ external environment for both the inflow and outflow of knowledge, thus the internal application of external knowledge and ideas and the external application of internal knowledge and ideas. Accordingly, Chesbrough and Crowther (2006:229) differentiate inbound and outbound open innovation, whereas Gassmann and Enkel (2006) refer to outside-in
processes and inside-out processes.\(^1\) For this research, solely the perspective of knowledge inflows is assumed.

Chesbrough’s (2003a, 2006a) understanding and definition of open innovation is a rather broad conceptualization of an innovation model, stressing the importance of firms systematically utilizing the external environment for their innovation purposes. Specifications of open innovation include the engagement in (strategic) alliances or generally, external networks (Dittrich and Duysters, 2007; Rothaermel and Alexandre, 2009), the integration of customers or users via various methods, such as lead-user workshop, toolkits, or idea competitions (Jeppesen, 2005; Piller and Walcher, 2006), the integration of suppliers, universities, and other research institutions (Becker and Dietz, 2004; Laursen and Salter, 2006), or the interaction with a broader, more general public through the means of “broadcast search” platforms (Lakhani et al., 2007) up to the developments around community-based innovations and the open source software development (Lakhani and von Hippel, 2003; von Hippel and von Krogh, 2003; West and Lakhani, 2008). All of these examples have in common that external knowledge is utilized for firms’ internal innovation aims and processes with the objective of improving innovation or firm performance. The efforts of firms to utilize external knowledge may differ with regard to source type and relationship governance type, e.g. contractual or non-contractual (Bahemia and Squire, 2010). In sum, however, all approaches resemble the core of what Chesbrough (2006a) has described as inbound open innovation activities. Thus, inbound open innovation can also be understood as a concept capturing firms’ levels of engagement with external sources (Bahemia and Squire, 2010:6). Or, as Lichtenthaler and Lichtenthaler (2009:1315) understand it, open innovation represents “[...] firms’ interorganizational knowledge transactions to extend their existing knowledge base”\(^2\).

\(^1\) Gassmann and Enkel (2006) introduce a third type of open innovation, the coupled process which describes a combination of the other two. Examples of this may be alliances that firms engage in. These require both knowledge inflows and outflows.

\(^2\) For more detailed and comprehensive descriptions and discussions of the open innovation concept, refer to recent review and discussion articles (Dahlander and Gann, 2010; Elmquist, Fredberg and Ollila, 2009; Gassmann, Enkel and Chesbrough, 2010; Huizingh, 2011; Lichtenthaler, 2011; Trott and Hartmann, 2009; Van de Vrande et al., 2010).
Open innovation and organizational knowledge search

The search for and utilization of external knowledge and ideas in internal innovation processes can be regarded as the core of the open innovation model (Laursen and Salter, 2006:132). Firms’ activities with regard to the connection with and exploitation of external knowledge sources can also be defined as firms’ knowledge search strategies (Sofka and Grimpe, 2010: 310). In other words, open innovation activities of firms find their expression in the specification of firms’ search strategies (Köhler et al., 2009:2).

Organizational search is part of the organizational learning processes and varies in its intents – organizations may search for new organizational designs, new production processes, or new ideas and knowledge for the purpose of new product development (Katila, 2002; Katila and Ahuja, 2002). Organizational search is conceptualized as an activity by which organizations solve problems, and in innovation search, firms attempt to recombine knowledge for the objective of generating new products (Katila, 2002:6). By engaging in organizational search, firms expand and renew their knowledge (base), which puts them in a position to be more innovative and successful (Levinthal and March, 1981; Katila and Ahuja, 2002; Rosenkopf and Nerkar; 2001). Organizational search is one of the central aspects for the comprehension of firms’ innovation success (Nelson and Winter, 1982). This is also highlighted by Drucker (2002:96) as innovation is the result of “[...] purposeful search for innovation opportunities”. In sum, organizational knowledge search can be understood as an “organization’s problem-solving activities that involve the creation and recombination of technological ideas” (Katila and Ahuja, 2002:1184).

Organizational search processes require a lot of resources in terms of time, skills, and financial resources (Cohen and Levinthal, 1990; Koput, 1997; Levinthal and March, 1993). In addition, organizational search activities may be constrained regarding the width of alternatives considered, as organizations and management may suffer from cognitive limitations (Ocasio, 1997; Gavetti and Levinthal, 2000). Accordingly, search processes of firms are often very localized, which means firms search along trajectories, within fields, and with regard to knowledge they already are familiar with (Stuart and Podolny, 1996). In order to stay competitive, however, firms need to overcome these search tendencies and renew their knowledge base, based on which skills, competences, and eventually product offerings are created (Leonard-Barton, 1992; Rosenkopf and Nerkar, 2001; Stuart and Podolny, 1996).
Regarding the limitations of firms’ search scope, previous research has offered several approaches for organizations to differentiate their search efforts and engage in more distant as opposed to local search. Organizational search may be differentiated according to the intent and the locus of their search efforts. Firms can engage in exploitative and explorative search, that is search within known or unknown (technology) fields (March, 1991). Firms can search for knowledge internally and externally of their firm boundaries (Rosenkopf and Nerkar, 2001; Rothaermel and Alexandre, 2009). Or firms may differentiate their search into supply or demand-side search, which refers to searching on the technology side or the market side of their offerings (Sidhu et al., 2007). Especially the expansion of firms’ search efforts beyond their organizational boundaries (Rosenkopf and Nerkar, 2001) has been shown to impact firms’ innovation performance strongly (Katila and Ahuja, 2002; Laursen and Salter, 2006; Leiponen and Helfat, 2010; Rothaermel and Alexandre, 2009).

In sum, the importance of knowledge search for firms’ innovation performance and the particular emphasis that research has given to the search for knowledge outside firms’ organizational borders adds to the relevance of the open innovation approach as discussed above. For the purposes of this research, open innovation is understood as:

*Firms’ activities aimed at the generation and utilization of external knowledge for internal innovation purposes which materialize in firms’ external knowledge search strategies* (Chesbrough, 2003a; Chesbrough, 2003b; Köhler et al., 2009).

### 2.1.2 Open innovation as external search breadth and depth and innovation performance

External knowledge search is constituted by two dimensions, i.e. search breadth and search depth (Laursen and Salter, 2006). The breadth dimension of a firm’s search captures the diversity of external inputs and is measured as the total amount of external sources being utilized by a single firm. Search depth is conceptualized as the intensity of the external relations a firm maintains. This is how deeply firms are drawing knowledge from a particular source (Laursen and Salter, 2006). Together these dimensions represent the degree of openness of a firm (Laursen and Salter, 2006:135). Both dimensions have been shown to exhibit an inverted U-shaped relation with innovation performance. That means, openness to external knowledge has positive
implications for innovation performance, yet these are limited to a certain extent of openness only, as from this point on firms may generate decreasing or even negative returns from openness (Laursen and Salter, 2006).

Increased exposure to external knowledge inputs through the means of greater search breadth or depth facilitates a firm's ability to generate valuable and innovative knowledge. As innovation requires the recombination of different elements of knowledge (Henderson and Clark, 1990; Katila and Ahuja, 2002), the more diverse the set of knowledge sources a firm draws upon in its innovative activities, the greater are the opportunities for the firm to combine knowledge in complementary and novel ways, and thus the more likely these activities will result in innovative output. In addition, external search depth contributes to innovation performance improvements through the positive effects that strong and stable relationships exert on the opportunities to acquire and develop new knowledge within relationships with external parties. Deep external relations, for instance, facilitate the development of trust, which is an important foundation for the transfer of tacit knowledge that has been found to be particularly important for innovation performance (Dyer and Nobeoka, 2000; Hansen, 1999; Lane et al., 2001). However, external search, either in form of breadth or depth, is not free of cost. Search activities and the relations to the respective external sources need to be managed, as well as the acquired knowledge inputs need to be processed by the organization in order to exert innovation impact. The constraints that firms face with regard to their processing capacities mainly derive from the restraints of attentive resources and the limitations of operational absorption capacities (Laursen and Salter, 2006:135).


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3 Please see Section 3.1 for a further discussion of the effects of search breadth and depth and their respective performance limitations.
externally, while search depth describes the extent to which a firm simply reuses its existing knowledge. Also here, both dimensions are found to exert a curvilinear relation with innovation performance (Katila and Ahuja, 2002). Search depth, hence reusing existing knowledge, has positive effects for innovation performance, as reapplying the existing knowledge leads to experience and proficiency and thus increases efficiency and efficacy because it makes search more predictable and less prone to errors – firms are better able to understand and evaluate the opportunities that the knowledge acquired through search provides (Katila and Ahuja, 2002:1184). Yet, these positive effects are limited and at one point the negative effects may outweigh the positive effects of further building on the same knowledge path. Paths of knowledge improvement may have technological limits and once these are reached, further reuse of that knowledge search path and the generation of further improvements may not be possible (Katila and Ahuja, 2002).

Search scope, on the other hand, facilitates innovation performance, as it enriches the available knowledge that a firm can draw from. Increasing search scope too far may again inhibit innovation performance improvement because the integration costs that the amount of knowledge entails may be too high, and thus the benefits may be compensated entirely. Another argument Katila and Ahuja (2002:1185) bring forward for explaining the assumed curvilinear relation is that innovation projects always imply the possibility of failure. The more innovation projects build on truly new knowledge, or the more new the knowledge is that innovation projects build upon, the more challenging it is for a firm to really understand the new knowledge requirements and hence, the less likely is innovation success (Katila and Ahuja, 2002:1185). Laursen and Salter (2006) build upon the work of Katila and Ahuja (2002) and the concept of search scope largely resembles that of search breadth.

Extant literature largely confirms the positive effects that external knowledge has for the innovation processes of firms. External parties, such as suppliers, customers, competitor firms, or universities, all exert positive performance effects when integrated into innovation processes (Becker and Dietz, 2004; Belderbos et al, 2004; Faems et al, 2005; Miotti and Sachwald, 2003; Nieto and Santamaria, 2007). The acquisition of external knowledge has positive implications for innovation and increasing a firm’s exposure to external sources and increasing the amount of sources knowledge acquired from
amplifies these positive effects (Amara and Landry, 2005; Faems et al., 2005; Roper et al., 2008; Tether and Tajar, 2008). According to Duysters and Lokshin (2011), the more external sources firms utilize and the more complex firms’ external search, the greater the potential benefits.

Yet, only few consider the potential downsides of exposure to external knowledge sources in an empirical fashion (Faems et al., 2010; Katila and Ahuja, 2002; Laursen and Salter, 2006; Rothaermel and Deeds, 2006; Rothaermel and Alexandre, 2009). Likewise, only little research addresses external knowledge utilization in terms of firms’ search breadth and depth (Bahemia and Squire, 2009; Chiang and Hung, 2010; Sofka and Grimpe, 2008). Bahemia and Squire (2009) conceptualize the impact of search breadth and depth as well as the combination of both, which they term “ambidexterity”, on innovation performance (Bahemia and Squire, 2009:11). Sofka and Grimpe (2008) investigate how absorptive capacity influences firms’ engagement in broad or deep search strategies, while Chiang and Hung (2010) investigate the effects of search breadth and depth for incremental and radical innovation performance.

**External search breadth and depth and different degrees of innovativeness of innovation performance**

In addition, search breadth and depth are found to have different effects for innovation performance when differentiating incremental and radical innovation performance. Laursen and Salter (2006:144-145) show that search breadth is rather beneficial for incremental innovation performance, whereas search depth exerts more positive influence on radical innovation performance. They argue that for the generation of radical innovations, truly novel ideas and knowledge are needed, which are usually held by only a few specific external sources. Approaching them and acquiring the respective knowledge requires firms to engage in specific and intense, hence deep relations with these sources (Laursen and Salter, 2006:136-137). Incremental innovations, however, are about developing further product offerings which are established in markets and regarding which a multitude of players engage in development efforts and possess relevant knowledge. Thus, the firms need to engage in broad search in order to tap into the wide array of potentially relevant knowledge sources (Laursen and Salter, 2006:136-137).
Chiang and Hung (2010) find search breadth to be positively related to radical innovation performance, whereas search depth is found to be positive for incremental innovation performance. Only through the utilization of a broad search approach can firms gather the amount and variety of information, knowledge, and ideas needed in order to generate truly novel approaches, solutions, and products (Chiang and Hung, 2010:294). Deep search relations require substantial resource investment. Thus, firms may only be able to engage in a smaller, more defined number of such external relations, which restricts the potential to finding truly novel knowledge (Chiang and Hung, 2010:294). This view finds confirmation in the assertions that ideas and knowledge are widely dispersed today and only broad, exploratory search may enable firms to acquire such knowledge (Chesbrough, 2006a; March, 1991; Powell et al., 1996). Likewise, the generation of innovation, especially radical innovation, requires the recombination of different, old, and new knowledge inputs (Schoenmakers and Duysters, 2010). Searching broadly increases the variety of the available knowledge pool (Katila and Ahuja, 2002:1185).

**Conclusion and research questions**

As argued above, search breadth and depth are two fundamental choices that firms can make with regard to their external knowledge search efforts. Both represent a specification of the (inbound) open innovation model. Firms can deliberately influence whether they search broadly or deeply and to which extent they do so, respectively. Breadth and depth differ regarding their intent, nature, and implementation and have strong implications for innovation performance. Especially, the performance implications of search breadth and depth justify a further examination. The proposition of both being curvilinearly related to innovation performance constitutes a deviation to the otherwise rather overly affirmative approach towards external knowledge utilization. At the same time, the assertion that external knowledge utilization is only of benefit up to a point is another aspect of discretion and strategic choice management needs to take into account when “designing” their external search efforts. Firms not only need to decide whether to search broadly and rather shallowly among a multitude of sources or deeply and rather intensely, but also need to bear in mind that both search activities are beneficial only with limitations, and thus they need to decide upon the extent of their respective search effort as well.
In sum, open innovation is a strategic activity to tap into external knowledge sources in order to improve innovation potential, and firms have substantial room for discretionary choices regarding the direction and extent of their external search. Prior research suggests positive and negative performance implications as well as different and opposing implications that external search has with regard to the degree of innovativeness of innovation output firms generate. In order to examine these issues, this thesis posits the following research questions:

**Research question #1:**
Which effects do external search breadth and depth have on innovation performance?

*(replication of findings in literature with different data sample)*

**Research question #2:**
Which effects do external search breadth and depth have for different degrees of innovativeness?

*(inconsistent findings in literature)*

### 2.2 Aligning of organizations and open innovation

#### 2.2.1 Evidence on management conditions and organizational requirements for open innovation

As the previous section has shown, literature and extant research have well documented the importance that external knowledge integration has for the possibilities of firms to improve their innovation performance (Chesbrough, 2003a; Duysters and Lokshin, 2011; Laursen and Salter, 2006; Lichtenthaler, 2011). Likewise, it has been acknowledged that external knowledge utilization has limitations with regard to its positive effects on firms’ innovation performance (Deeds and Hill, 1996; Duysters and Lokshin, 2011; Rothaermel and Deeds, 2006). It rather exerts its influence following an inverted U-shaped relation (Katila and Ahuja, 2002; Knoben and Oerlemans, 2010; Laursen and Salter, 2006; Rothaermel and Alexandre, 2009). Hence, open innovation is of major importance for firms’ innovation management practices and strategies but must not be taken as the sole remedy to increase firms’ innovation potential. Open innovation does not imply that firms are relieved of the need to coordinate and structure their innovation activities, but it requires appropriate measures taken by management to enhance a firm’s ability to process external knowledge internally (Bergman et al.,
Hence, open innovation research appears to be incomplete on the “structural perspective” (Laursen and Salter, 2004:1203). Future studies should investigate "how different organizations organize their search processes” (Laursen and Salter, 2006:147). This call for a more thorough investigation of the management and organization of external knowledge utilization in firms has recently been repeated. Bianchi et al. (2011:23) assert that “there are few contributions that look at how firms organise themselves to make the most out of Open Innovation, i.e. on the organisational implications of this emerging innovation management paradigm”. Lichtenthaler (2011:85-86) sees a need for “[…] further insights into practices […] for managing open innovation processes”. Dahlander and Gann (2010:8) ask why some firms gain more from openness than others and constitute that “This is a fundamental question on which there is surprisingly limited evidence”. They further assert that this may have to do with the mechanisms that firms use to benefit from open innovation (Dahlander and Gann, 2010:9). Further, also Gassmann (2006:223) states that “[…] there is a need for a contingency approach regarding the management of innovation” and concluded that “Which of the factors that drive higher performance are preferred by open and which by closed innovation models need to be determined.”

Lichtenthaler and Ernst (2009:51) remark that research dealing with appropriate management for open innovation needs to be further emphasized. Yet, in a review of literature investigating aspects of open innovation, Brunswicker (2011:46) asserts that “[…] the role of organizational practices for innovation in helping a firm to capture the value from openness is hardly investigated”. This is confirmed by Dahlander and Gann (2010:702), who find that until today large-scale quantitative examinations of open innovation are largely missing. Thus, there is a gap which cripples theoretical advancement and the generation of more substantial knowledge about the application of open innovation. This in turn puts a strain on recommendations which can be made for the application of open innovation by practitioners.

Partly, these recent calls for more research on organizing for open innovation have been addressed by earlier studies already. Yet, many of the insights that research has generated on management or contingency issues regarding open innovation stem from various case studies. For instance, Sakkab (2002) identifies the definition of a strategy and the design of an overall open innovation system based on processes for open
innovation as crucial. Huston and Sakkab (2006:66) identify a variety of aspects to be important drivers of Procter & Gamble’s success with its open innovation strategy - crucial are openness to outside ideas and internal exchange, availability of internal resources for and their dedication to open innovation activities, the definition of responsibilities for open innovation as well as commitment by management and the introduction of open innovation into strategy formulation. This is confirmed by Chesbrough and Crowther (2006:233-234), who assert that “key success factors” for open innovation are firms’ cultures and organizational beliefs as well as the implementation of open innovation as strategic and top-down initiatives. Further, they report that firms did not install entirely new management systems but adapted existing ones to open innovation. This includes the adaptation of structures and processes, in which the role of specific individuals, such as champions, and the definition of procedures and incentive systems aligned with open innovation, were found to be most important. Also Witzeman et al. (2006:19) see leadership, cultural adaptation, and the definition of processes as crucial prerequisites for successful open innovation. Lazarotti and Manzini (2009:629) confirm this, as they find that open innovators exhibit a participative managerial style and precisely defined organizational and procedural arrangement. In addition, they identify high internal degrees of involvement of employees and management as a condition for open innovation. Another aspect is added by Dodgson et al. (2006:343), who describe the importance of aiding open innovation adoption by the utilization of different applications of information technology.

Recent conceptual and empirical research adds to these findings. For instance, Lichtenthaler and Ernst (2006) argue that organizational beliefs, such as the occurrence of the “not-invented-here”-syndrome, negatively affect open innovation implementation. This finds confirmation in the study by Herzog and Leker (2010:335), who find NIH to be an important aspect for open innovation. A case study by Chiaroni et al. (2010:242) describes that before applying open innovation, firms need to change their structural arrangements, the evaluation processes employed, and their knowledge management systems. In one of the few quantitative empirical studies relying on the conception of new managerial practices, Foss et al. (2011:994-995) find that open innovation, understood here as interaction with customers, benefits from the adaptation of aspects such as delegation, communication, and incentives systems. Finally, adding
still another aspect, Lichtenthaler and Ernst (2009) find innovation strategy to be relevant for the success impact of inbound innovation.

Summing up, these studies have identified a variety of conditions or factors relevant for open innovation. These can be subsumed as concerning firms’ organizational structures or structural arrangements (such as delegation, specific roles and responsibilities, or the definition of processes), their culture, and firms’ strategies. Beyond that, the deployment of certain methods, systems, and tools as well as the employment of certain styles of leadership was also found to be of considerable importance.

2.2.2 Management of open innovation and relation to absorptive capacity

Another stream of literature discusses the need for firms to develop certain capabilities in order to explore outside knowledge and to gain from open innovation (Lichtenthaler, 2011:80). Most prominently discussed in this respect is the ability of firms to acquire and integrate external knowledge. As such, a firm’s absorptive capacity is of particular importance (Lichtenthaler and Lichtenthaler, 2009:1318). This is also reflected by other research which also points to the implications of absorptive capacity for open innovation (Foss et al., 2011: 982; Laursen and Salter, 2006:137; Lichtenthaler and Ernst, 2009:50; Rothenberg and Alexandre, 2009:763-764; Spithoven et al., 2011: 11; West and Gallagher, 2006:321).

The term absorptive capacity was introduced by Cohen and Levinthal (1989, 1990) and refers to firms’ “[...] ability to recognize external knowledge, assimilate and apply it [...]”, respectively, for the generation of successful innovation (Cohen and Levinthal, 1990:128). The absorptive capacity that a firm possesses can be referred to as its existing knowledge base and is a product of firms’ R&D activities and their respective learning and knowledge accumulation (Cohen and Levinthal, 1990). As such, absorptive capacity facilitates the knowledge utilization, since the existing knowledge firms possess aids in understanding and applying new knowledge (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998).

Cohen and Levinthal (1990:133) make a distinction between “inward-looking” and “outward-looking” absorptive capacity, with the latter referring to firms’ actual interaction with external knowledge sources and the former referring to firms’ internal knowledge procession. Similarly, Knudsen et al., (2001:2) differentiate between “access
and utilisation of knowledge”, and Lichtenthaler and Ernst (2006:368) also resemble this distinction when they refer to the prerequisites of firms successfully realizing the opportunities of open innovation and demand that “[...] companies should establish an integrated knowledge management approach, which includes the internal management of the firm’s knowledge as well as the knowledge transactions with other organisations”. In line with this, we assume a differentiation between search and integration regarding firms’ knowledge utilization activities.

Most research utilizes measures such as R&D expenditures or the number of employees in R&D departments to capture a firm’s absorptive capacity (Foss et al. 2011:982; Volberda et al., 2010:937). But absorptive capacity also has managerial or organizational aspects. These were already acknowledged by Cohen and Levinthal (1990:131) but received only little attention in subsequent research (Foss et al., 2011:982). Lane and Lubatkin (1998), recognize the organizational aspect of absorptive capacity, as they determine the importance of structural similarities between knowledge exchange partners for the exchange’s respective success. Jansen et al. (2005), confirm the important implications of structural and cultural conditions for an organization’s absorptive capacity in their examination of different organizational aspects and their impact on distinct dimensions of absorptive capacity.

As mentioned before, research on open innovation oftentimes refers to absorptive capacity and according to Vanhaverbeke et al. (2007:2), “[...] absorptive capacity and the outside-in dimension of open innovation are necessarily linked to each other.” Though research on absorptive capacity offers valuable insights into the organizational preconditions of successful knowledge integration, it leaves considerable conceptual and empirical aspects unresolved (Volberda et al., 2010:943) and does not directly connect to open innovation and firms’ efforts to engage with outside knowledge sources (Vanhaverbeke et al., 2007:16). While research on absorptive capacity is more specific about the importance of internal knowledge application and the contingency conditions for respective success, it oftentimes does not specify on firms’ external search strategies employed or sources utilized. Research on open innovation, on the other hand, is more specific on the actual knowledge search strategies, but offers only little insights about management aspects and conditions upon which success is contingent (Bianchi et al., 2011:23; Lichtenthaler, 2011:85-86; Vanhaverbeke et al., 2007:16). Thus, our study
aims to directly investigate the contingency conditions for the facilitation of external knowledge search strategies and the application of open innovation.

2.2.3 Theoretical and conceptual background of organizational alignment

Lichtenthaler and Lichtenthaler (2009:1328) and Lichtenthaler (2011:88) argue for the need of firms to realign their organizations with open innovation. In order to investigate conditions for open innovation facilitation, this study investigates how firms can align their organizations with open innovation. The notion of alignment stems from research which defines the origins for sustainable firm performance to lay in an alignment of various organizational variables, such as strategy, structure, and culture (Semler, 1997:27). This literature sees the origins of firm performance in the effective and efficient pursuit of firms’ goals, which in turn is supported by a “systematic agreement among strategy, structure, and culture within an organization” (Semler, 1997:28). In other words, firms’ success does not exclusively depend on any single factor, such as the definition of the correct strategy, or the possession of superior production skills and processes, but rather on the appropriate creation of an overall system in which the elements are mutually adjusted. The notion of alignment describes widely the same as terms such as “match”, “congruence”, and “fit” (Semler, 1997:24; Venkatraman (1989:423). This study refers in the following to the notion of fit and its respective analysis procedures for the investigation of organizational alignment with open innovation.

The concept of fit is largely based in the domain of contingency theory. Contingency theory proposes that there is no one right way to design an organization, but that certain organizational settings fit better given the circumstances (Currie and Suhomlinova, 2007). According to Galbraith (1973:2), there are several ways of organizing a firm and not each of those is equally effective. However, contingency theory assumes that depending on the existence of certain commonalities, dominant patterns or organizations may be identified (Zeithaml et al., 1988:37). Thus, whether a specific organizational setting is appropriate or not depends on the contextual situation, hence certain contingencies. An organizational contingency factor or variable is best described as the third variable in a relation between a variable describing any organizational characteristics or activities and the organization’s respective performance (Currie and
Suhomlinova, 2007). If an organizational characteristic is in fit with a contingency factor, superior performance should be the result.

Put differently, contingency approaches assume that performance is dependent upon a favorable relation between organizational elements, while these elements are contingent upon certain other variables regarding their effectiveness (Drazin and Van de Ven, 1985). For instance, the effectiveness of delegating decision making to individual business units may depend in its performance impact, hence its effectiveness, on the appropriate culture of the firm, encouraging own decision making and possible deviance, on the firm’s strategy emphasizing speed or closeness to customers, or on the general business environment requiring close customer interactions.

**Analysis and identification of organizational alignment**

Following Drazin and Van de Ven (1985:515), the notion of fit can be conceptualized in three different ways. The selection approach assumes fit or congruence between contingency factors and organizational characteristics on the basis of the identification of an alignment constituted by significant correlations between the respective variables. The interaction approach, or the bivariate interpretation of fit, assumes fit to be “an interaction effect of organizational context and structure on performance” (Drazin and Van de Ven, 1985:515). Hence, fit is established only if there is a significant performance impact of the contingency-variable relation. This approach intends to determine how single organizational characteristics are affected by single contingencies and how they together influence performance (Drazin and Van de Ven, 1985:519).

Since the reality of organizations is characterized by multiple organizational variables, contingencies, and performance aspects, a third approach is proposed – the systems approach (Drazin and Van de Ven, 1985:519). Herein, it is assumed that fit is established by congruence between a set of internal variables which are consistent or in fit among themselves and another set of contingencies. Certain structural arrangements may require being accompanied by the employment of certain methods and tools – the implementation of decentralized structures, for instance, may require the implementation of certain incentive systems and both in turn may be more appropriate for dynamic environments (Hitt and Brynjolfsson, 1997: 98). Thus, a distinction can be made between the need to align internal variables and external variables, which resembles conceptions of fit analysis that differentiate between horizontal and vertical
fit (Becker and Huselid, 2006:909) or internal and external fit (Zajac et al., 2000:441). Contingency analyses adopting a systems approach are thus multi-contingency approaches and extend bivariate conceptions of contingency theory to include multiple variables (Burton et al., 2002:1462).

Recent studies informed by contingency theory have adopted this comprehensive perspective, albeit not explicitly referring to the external-internal or vertical-horizontal dichotomy (Burton et al., 2002; Olson et al. 2005; Vorhies and Morgan, 2003; Zajac et al., 2000). Others again have adopted bivariate conceptions of fit and investigated the alignment of only a few variables, like Birkinshaw et al. (2002:275), who sought to determine the fit between knowledge characteristics and organizational structure. While acknowledging the shift in contingency theory towards “configurational” approaches, Birkinshaw et al. (2002:275) adopt a bivariate conception of fit, as they deem this approach to be well suited for the analysis of single contingency relations. Miller et al. (1992:159) assert that a sequential approach for establishing external and internal fit may be more feasible than aiming at obtaining overall fit. They find firms with internal fit often to be in external misfit and vice versa (Miller et al., 1992:175), hence aspects of obtaining external and internal fit may be concurrent to each other.

According to Drazin and Van de Ven (1985:523) and Henderson and Venkatraman (1990:13), fit analyses adopting an interaction approach are useful, as they allow identifying certain bivariate relationships and their effects for performance, thereby focusing the attention of firms’ management and the allocation of resources. In addition, Fiss (2007:1180) describes that existing multicontingency or configurational approaches suffer from methodological shortcomings and the theoretical challenge to compile configurations as well as dissect individual elements’ influence. This is also remarked by Venkatraman (1989:432-433), who sees the critical tasks of defining which variables should be part of a multicontingency model, defining their respective relations, as well as identifying their respective performance impact. It may well be that configurations impact performance, but it may not be clear if they do so due to the whole or if only few single variables are actually important (Fiss, 2007:1182).

An advantage of bivariate approaches and perhaps as a first step towards the generation of more comprehensive organizational configurations, bivariate fit analyses may aid identifying which variables matter and have which effects, as they allow for precise
isolations of specific effects and theoretical links (Venkatraman and Prescott, 1990:3). Reviewing advantages and disadvantages of configuration approaches versus bivariate approaches, Wolf (2003:356) concludes that bivariate or interactionist approaches may be better suited to unveil actionable relations. Configurational approaches assume a multitude of interrelated variables to be relevant. This adds complexity and it may not be possible to reliably uncover actual relations, determine single factors’ relevance, and thus sensible overall configurations (Wolf, 2003:356).

In addition to defining the conceptualization of fit adopted for analysis reasons, the analytical understanding of fit needs to be addressed. Venkatraman (1989) proposes six different types of how to analytically capture fit. Most suitable and common for analyzing bivariate fit situations is the operationalization of fit as moderation. The effect of any predictor variable for a performance variable is dependent on a third variable, the moderator or contingency (Venkatraman, 1989: 424). The formal representation of that relation would be stated as $Y = f(X, Z, X*Z)$, where $Y$ is the dependent performance variable, $X$ represents the independent (predictor) variable, and $Z$ the second independent (response) variable (Venkatraman, 1989:425). Fit as interaction now assumes that the effect of $X$ on $Y$ depends on the level of $Z$ and is statistically determined through the existence of a significant interaction effect between $X$ and $Z$, thus a significant term $X*Z$. In conclusion, this study adopts an understanding of fit based on the interaction approach, and thus examines bivariate relations based on analyzing respective moderation effects.

**Elements of investigation for the analysis of organizational alignment and research questions**

When describing organizations as configurations of basic elements, attributes such as strategies and structures are most often referred to (Ketchen et al., 1993:1278). The most known and most fundamental conceptions of organizations in management research all include attributes such as organizations’ strategies, structures, and cultures (Mintzberg, 1979; Miles and Snow, 1978). Likewise, the conception of different organizational types, such as organic and mechanistic by Burns and Stalker (1961), utilizes elements of strategy and structure. In contingency theory, the central aspects of analysis are the fit between firms’ structures and processes and the context, which contains aspects such as culture, environment, or size (Drazin and Van de Ven, 1985:
Burton et al. (2002:1463) describe a model of multiple contingencies containing structure, strategy, and culture as central elements. Building on the conceptualization by Burton et al. (2002) and Burton and Obel (2004), we focus our analysis on the dimensions of organizational structure as well as organizational culture and strategy as contingency variables. Looking at the literature in the realm of innovation-related topics, similar relevant contingency aspects can be found (Damanpour, 1991; Damanpour, 1996; Germain, 1996; Liker et al., 1999; Souder and Song, 1997).

Before the background of open innovation, Lichtenthaler and Ernst (2006:368) assert that “[...] companies have to establish organizational processes and structures that facilitate knowledge transactions [...]” as well as undergo “[...] considerable changes in a company’s [...] strategy and culture”. As discussed before, the literature examining management aspects of open innovation recurrently identified aspects of structures, culture, and strategy as important, too. In this respect, however, research remains being encouraged - Lichtenthaler (2011:86) as well as Van de Vrande et al. (2010:230) called for investigating firms’ strategies and cultures as well as structures. Previous research yet also has raised concerns about overwhelming organizations with the calls for adaptation. Lichtenthaler (2011:88) is concerned that “[...] To avoid excessive initial learning periods, managers may try to build on a firm’s existing organizational processes and structures rather than implementing entirely new open innovation processes.”

Thus, we investigate the contingency effects of “traditional” attributes of firms’ organization, namely their structure, culture, and strategy for the performance implications of firms’ external search activities. Concluding, the third question guiding this research is as follows:

**Research question #3:**

Which contingency factors influence the performance effects open innovation? (extension of literature)

3a) How does organizational **structure** matter?

3b) How does organizational **culture** matter?

3c) How does innovation **strategy** matter?
In sum, this research investigates the effects of open innovation for companies’ innovation performance and how certain contingency factors representing choices of managers to design and align their organization influence these effects (Figure 4). We distinguish between external knowledge search breadth and search depth and investigate their respective contribution to overall innovation performance as well as to incremental and radical innovation performance (Study I). In a further step, this research establishes a contingency framework to analyze certain organizational features. We apply a bivariate conception of fit analyses for this research, yet we include multiple contingency elements in the analysis. The implications of organizational structure as well as culture and strategy are examined. Hence, we ask how external search breadth and depth align with the design of firms’ organizational structure (Study II). Further, we investigate how external search breadth and depth align with organizational culture and strategy (Studies III and IV).

Figure 4: Overall research model

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4 In contingency theory terms, the former study may represent an investigation of horizontal or internal fit, while the latter two studies refer to vertical or external fit.

5 For the purpose of providing a comprehensive overview, Figure 4 already contains the individual examination variables. These are introduced and described in more detail in Sections 3.1 to 3.4.
3 Hypotheses development

3.1 External knowledge search strategies and innovation performance

As discussed before, firms’ external knowledge utilization activities, hence the external linkages firms engage in and their respective knowledge integration efforts, have developed into one of the core issues in the contemporary innovation management literature (Huizingh, 2010:2; Trott and Hartmann, 2009:715; Van de Vrande et al., 2010:223). As a result, firm-focused innovation management perspectives have been replaced by a more comprehensive perspective on innovation, emphasizing the distributed and interactive character of the innovation process (Laursen and Salter, 2006). Laursen and Salter (2006:131) refer to open innovation as strategy for external knowledge search. While there clearly are positive effects of extended external search efforts for innovation performance, firms may risk “over-searching” their environment or rely too heavily on external knowledge sources (Laursen and Salter, 2006:135). Thus, openness has limitations with regard to its positive performance implications. When extending external search too far, firms may even generate negative performance implications.

Yet, the actual design of firms’ external search is at the discretion of companies’ management and its direction and extent has been shown to have considerable implications for innovation performance in terms of degree of innovativeness and magnitude of performance. This relevance of external knowledge search indicates the need for strengthening the evidence about external knowledge search’s performance effects. Therefore, we replicate the hypotheses about the effects of external search breadth and depth and investigate the effects on a sample we generated in the German manufacturing industry. In addition, this replication and the hypothesized relations are the base and starting point for the further investigations of management approaches towards the utilization of open innovation in this research (Figure 5).
3.1.1 External search breadth and innovation performance

The breadth dimension of knowledge search is defined as "the number of different search channels that a firm draws upon in its innovative activities" (Laursen and Salter, 2006:134). Based on this definition, search breadth describes the diversity of a firm's search activities. Scholars claim that this type of search provides flexibility and is more likely to remain more general in its focus, and hence provides the firm with a comprehensive overview of available opportunities (Chiang and Hung, 2010; Sofka and Grimpe, 2008). Similar, research on inter-organizational networks is arguing that valuable knowledge which is necessary to achieve competitive advantage is broadly distributed in the firm's environment. Hence, the amount of network ties, or tie diversity, is seen as a salient predictor of a firm's innovation performance (Powell and Brantley, 1992).

Tie diversity is, in its conception, similar to the breadth dimension of organizational search. Tie diversity and external search breadth provide the firm with complementary knowledge (Leiponen, 2005) and at the same time lower the risk of information redundancy and risks from unforeseen developments. Exposure to knowledge from heterogeneous domains allows considering multiple perspectives and thus adds to the
firm’s repertoire of innovation ideas. In addition, knowledge inflows from diverse knowledge domains can help the firm to overcome tendencies to favor familiar over unfamiliar knowledge, and to thus avoid getting stuck in a familiarity trap (Ahuja and Lampert, 2001). Since innovations are considered to be results of the recombination of familiar and unfamiliar elements of knowledge (Henderson and Clark, 1990; Katila and Ahuja, 2002), the more diverse the set of knowledge sources that a firm draws upon in its innovative activities, the greater are the opportunities for the firm to combine knowledge in complementary and novel ways, and thus the more likely these activities are to result in innovative output.

Yet, there are negative consequences of too much external knowledge search. These can be attributed to firms’ constrained capacities to absorb knowledge (Cohen and Levinthal, 1989, 1990; Koput, 1997). Highlighting the cognitive limitations of managers, the attention-based theory of the firm (Ocasio, 1997) suggests that managerial attention is a limited resource and that managers therefore need to concentrate their efforts and energy. Due to the scarceness of attention, managers can only concentrate on a limited number of issues and at the same time sustain an acceptable level of performance (Ocasio, 1997). As a consequence, with increasing exposure to external knowledge sources, firms face an attention and resource allocation problem due to information overflow. Ever more external knowledge acquisition will lead to knowledge increasingly being underutilized, not fully unveiling its potential, whereas the acquisition efforts and cost rise at the same time with the increase in acquisition quantity. Thus, the use of external knowledge sources is likely to exhibit decreasing marginal returns regarding innovation performance. Concluding from the above reasoning, and in line with Laursen and Salter (2006), we propose the following hypothesis:

**Hypothesis 1**: External search breadth exhibits a curvilinear relationship (taking an inverted U-shape) to innovation performance.

### 3.1.2 External search depth and innovation performance

Additionally to the extent of a firm’s search strategy in terms of the sheer number of external sources, Laursen and Salter (2006) define external search depth as a further dimension of knowledge search, which is the degree of intensity with which firms draw
knowledge from external sources. External search depth is the number of external partners that are deeply integrated into a firm's innovation activities. Literature on firms' but also social networks employs the dimension of tie strength to assess the intensity of the relationship between a focal firm and its external partners (Oerlemans and Knoben, 2010a; Van Wijk et al., 2008). Tie strength distinguishes between weak and strong ties and increases with the frequency of interactions between partners. So, while weak ties are based on rather occasional and shallow interactions, strong network ties describe more frequent and intense relationships (Hansen, 1999; Oerlemans and Knoben, 2010a). The close correspondence between the deep linkages described by Laursen and Salter (2006) and the strong network ties addressed in the social capital and network literature leads to the conclusion that external search depth is conceptually similar to the count of strong ties that a firm maintains within its network of external knowledge sources.

Tie strength, i.e. strong and weak ties, is related to different performance implications. While the attainability of higher levels of overall knowledge transfer is ascribed to strong network ties (Reagans and McEvily, 2003), weak ties are said to offer pathways to different knowledge domains, and are thus more likely to offer novel information (Granovetter, 1973; Tiwana, 2008). However, the close and frequent interactions taking place in strong tie relationships facilitate the development of mutual trust which serves as a catalyst for the transfer of tacit knowledge. The latter has been found to be particularly important for innovation performance (Dyer and Nobeoka, 2000; Hansen, 1999; Lane et al., 2001).

Hence, most of the knowledge transferred via strong ties is tacit in character, whereas the knowledge transferred in weak ties is very likely to be rather codified. At the same time, the establishment and maintenance of such deep linkages with external actors requires considerable investment (Laursen and Salter, 2006; Oerlemans and Knoben, 2010a; Reagan and McEvily, 2003). These investments include time consuming and frequent face-to-face interactions as well as higher coordination efforts, or the creation of a mutual understanding and common knowledge (Hansen, 1999; Reagan and McEvily, 2003).

Summarizing, deep search activities are likely to generate novel and innovative knowledge due to being more conducive to the transfer of tacit knowledge, yet these advantages are compensated by the costliness and complexity of creating and
maintaining deep relationships with external partners. We expect diminishing marginal returns to external search depth, meaning that firms which maintain too many intensive relationships will exhibit lower innovation performance. Accordingly, it is hypothesized:

**Hypothesis 2:** External search depth exhibits a curvilinear relationship (taking an inverted U-shape) to innovation performance.

### 3.1.3 Radical and incremental innovation and external search

The effects that external search breadth and depth have for overall innovation performance having been postulated, external knowledge search can be further differentiated regarding the degree of innovativeness that the innovating firm achieves with its respective search strategy. This bears importance, as the different innovation types that firms can realize have different impacts on their overall performance and eventual survival (Garcia and Calantone, 2002).

A widely accepted typology of innovation outcomes distinguishes radical and incremental innovation (Laursen and Salter, 2006). Radical innovations usually are associated with the biggest long-term performance effects (Marsili and Salter, 2005). However, they require the biggest departure from technologies, processes, and competencies employed so far in the firm (Anderson and Tushman, 1990; Tushman and Anderson, 1986). Incremental innovations concern the development of existing products and offerings and build widely on the existing technologies and competencies (Henderson and Clark, 1990). Following Laursen and Salter (2006), radical innovation implies the cooperation with only a few external sources but therefore on a high intensity level. That is, because radical innovations constitute a comprehensive departure from current proceedings in an industry and usually involve completely new developments, only a few external sources may be available for cooperation. For example, the developments in the biotechnology sector are focused around one single external source, which is universities (Laursen and Salter, 2006). The development of incremental innovations is common sense in an industry and usually several different actors possess knowledge regarding specific aspects of the technology. Hence, several external parties with valuable and necessary knowledge inputs exist, and firms need to be able to utilize several external sources.
Following this, broad external search is more conducive to incremental innovation, whereas deep external search is more conducive to radical innovation. Similar to Laursen and Salter (2006:137), we hypothesize:

**Hypothesis 3:** The more radical the innovation, the less effective external search breadth will be in influencing innovative performance.

**Hypothesis 4:** The more radical the innovation, the more effective external search depth will be in influencing innovative performance.

### 3.2 Organizational structures, external search, and innovation performance

Hitherto, only little research exists investigating possible levers of firms to increase the potential to which they benefit from external knowledge (Lichtenthaler and Ernst, 2009). To fill this gap, this section discusses contingency factors of open innovation and openness (Gassmann, 2006; Gassmann, et al., 2010). Recent research highlighted companies’ organization of external knowledge utilization as one major aspect to shed light on (Bianchi et al., 2011:23; Laursen and Salter, 2006:147; Lichtenthaler, 2011:86; Van de Vrande et al., 2010:230). In this respect, the structure that an organization adopts plays a major role as a determinant of successful knowledge search, transfer, and application (Mintzberg, 1979; Pertusa-Ortega, et. al. 2010; Rivkin and Siggelkow, 2003). Thus, this section emphasizes three variables constituting an organization’s structure – specialization, formalization, and decentralization (Mintzberg, 1979; Pertusa-Ortega et al., 2010; Volberda, 1998) – and examines the effects these have for the relation between external knowledge search and innovation performance (Figure 6).
3.2.1 Organizational design and implications for firm performance

Organizational design has been shown to impact firms’ effectiveness regarding the communication and processing of information (Aldrich, 1999; Clark and Fujimoto, 1991; Galbraith and Nathanson, 1978; Mintzberg et al., 1995; Olson et al., 1995). Also, a firm’s organizational structure has been connected to the ability of this firm to innovate (Argyres and Silverman, 2004; Damanpour, 1991; Eisenhardt and Tabrizi, 1995; Tidd et al., 1997), to absorb, proceed upon, and learn from external knowledge (Jansen et al., 2005; Lichtenthaler and Lichtenthaler, 2009; Van den Bosch et al., 1999), and to relate to external parties (Lane and Lubatkin, 1998). These aspects all represent ingredients for successful open innovation, yet the question remains as to how the organizational structure that a firm has implemented supports its open innovation activities directly. Hence in this section we investigate how firms’ broad or deep external search for innovation-relevant knowledge and the subsequent impact on innovation performance are affected by elements of organizational design.

Research has suggested that external knowledge can only be utilized successfully when firms manage to modify their organizational structure to facilitate open innovation (Bianchi et al., 2011; Dahlander and Gann, 2010). The potential to process information
between internal units and these units and the external environment, respectively, is to a large extent determined by firms’ organizational structures (Cohen and Levinthal, 1990; Tushman and Nadler, 1978; Van den Bosch et al., 1999). This highlights the importance of a firm's structural composition in the context of knowledge integration and innovation.

Likewise, Piller and Ihl (2009) propose that firms can support open innovation by means of an appropriate organizational design. Looking at different dimensions of organizational structure, the authors argue that there are favorable levels of single structural variables that create an adequate environment to foster external knowledge integration, organizational learning, and thus the generation of innovative outputs. As organizational learning happens through the learning of individuals within an organizational context facilitating or inhibiting individual learning activities (Glynn, 1996; Lane and Lubatkin, 1998; Pertusa-Ortega et al., 2010), organizational learning is seen to be contingent upon the organizational structure of the firm (Lane et al., 2006).

Organizational learning is largely dependent on a firm's contacts with external knowledge sources (Lane and Lubatkin, 1998). As a consequence, organizational search and a firm’s openness towards external sources are seen as important mechanisms for organizational learning (Lane et al., 2006). In this regard, several studies have investigated the influence of organizational structure on a firm's search behavior (Cassiman and Valentini, 2009; Siggelkow and Levinthal, 2003; Zhang et al., 2007). While Siggelkow and Levinthal (2003) state that organizational structure is an important general determinant of search processes, Zhang et al. (2007) find more specifically that it is the centralization of a firm's R&D organizational structure that leads to a higher probability of engaging in relationships with external partners. A higher degree of centralization is thus associated with increased openness. Likewise, De Boer et al. (1999) suggest that organizational structures embodied in basic organizational forms affects a firm’s ability to search for and utilize external knowledge. The authors compare three basic organizational forms (functional form, divisional form, matrix form) concerning their knowledge integration potential, and suggest the matrix form to offer the appropriate levels of flexibility and scope of knowledge integration in order to create knowledge integration capacity.

Besides the ability to identify and source external knowledge, organizational learning is
shaped by a firm's ability to link external and internal knowledge (Bessant and Venables, 2008). Cohen and Levinthal (1990) refer to this capability as the inward-looking component of a firm's absorptive capacity, and highlight its importance for effective organizational learning, as it facilitates efficient internal knowledge processing mechanisms (i.e. internal knowledge sharing). In this regard, previous studies have put forward the importance of organizational structure for inter-unit knowledge sharing (Tsai, 2002; Willem and Buelens, 2006). Organizational structure affects internal communication processes (Guetzkow, 1965) and also the likelihood of effective internal knowledge management (Lam, 2000; Nonaka and Takeuchi, 1995; Pertusa-Ortega et al., 2010).

Following the argument of Cohen and Levinthal (1990), external search strategies remain ineffective without the ability of the firm to communicate and share internally what has been absorbed from the environment. In other words, even if a firm successfully manages to search for knowledge externally and to establish and maintain linkages to external knowledge sources, the firm will not be able to achieve higher levels of innovation performance in the absence of internal knowledge-processing capabilities. Since a firm's openness and internal processes that facilitate organizational learning are both contingent upon the firm's organizational structure, it seems to be reasonable to expect a moderating effect of organizational structure on the relationship between openness and innovation performance.

The necessity to facilitate organizational learning and innovation by means of an appropriate organizational design is underpinned by the suggestion of various structural configurations, or so called organizational models, such as the J-form (Lam, 2000), the hypertext model (Nonaka and Takeuchi, 1995), or the N-form (Hedlund, 1994). Classical conceptions suggest organizational forms such as “mechanistic” and “organic” organizations (Burns and Stalker, 1961) or “organizational archetypes” identified by Mintzberg (1979) such as “simple structure, machine bureaucracy, professional bureaucracy, divisionalised form and adhocracy”.

According to Mintzberg (1980:322) and Walker and Ruekert (1987:27), these various ideal-type organizational forms can be resembled by a few core dimensions of organizational design. Although each of these alternative configurations highlights different elements, they overlap in fundamental design dimensions which can be found
as the most prevalent dimensions of organizational design in much of the extant research (Donaldson, 2006; Fredrickson, 1986; Miller and Dröge, 1986; Mintzberg, 1979; Olson et al., 2005; Volberda, 1996, 1998; Vorhies and Morgan, 2003; Walker and Ruekert, 1987).

Following Rivkin and Siggelkow (2003:293), who use a conceptualization by Nadler and Tushman (1967), three “classes of organizational elements” can be identified - “structural links, systems and processes, and grouping”. The first relates to organizations’ “vertical hierarchies” which can be understood as degree of decentralization of decision making, while “systems and processes” resembles formal procedures to guide decision making efforts and “grouping” refers to the aggregation of organizational tasks and units (Rivkin and Siggelkow, 2003:293). In a conceptualization of fit-misfit situations of organizations, Burton et al. (2002:1463) suggest centralization, formalization, and differentiation as central “properties” of the organizational structure for a respective analysis. The importance and centrality of these factors to analyses of organizational design is confirmed by Mintzberg (1980:325), who identifies these dimensions as core parameters of organizational design and Damanpour (1991:558), who identifies these factors, among others, as key “determinants” for innovation. Further, Kieser and Kubicek (1983:79) see specialization, delegation, and formalization as foundational elements of a conceptualization of organizational structure. Pierce and Delbecq (1977:29-31) suggest differentiation, decentralization, and formalization to be influential for certain innovation process steps. Similarly, Calantone et al. (2010:1070) suggest “[…] (1) (de)centralization; (2) (in)formalization; and (3) functional differentiation vs. integration […]” to be “the three key […] structure dimensions […]”.

Following this discussion and differentiation, we suggest that organizational design has important effects for the pursuit of open innovation, i.e. the search and integration of external knowledge for innovation purposes. Organizational structure and its central dimensions are proposed to be important contingency factors for the openness-innovation performance relation. Hence, we will conduct an analysis of specialization, formalization, and decentralization and their respective moderation effects for this relation. The following sections will explore their effects individually.
3.2.2 Moderation effects of organizational specialization

The division of tasks and activities into subtasks and the assignment of these tasks to specific members or units of the organization as their prime activity is referred to as “specialization” (Mintzberg, 1979; Mintzberg et al., 2003). In firms that exhibit high degrees of specialization (sometimes also called "differentiation"), increased division of labor creates groups of specialists, who direct their efforts to a well-defined but limited range of activities (Ruekert et al., 1985). In such an environment, tasks are "performed by someone with that function and no other" (Pugh et al., 1968:73).

Scholars have associated specialization with positive effects for firm performance. Specialization (a high level of horizontal differentiation) leads to higher organizational complexity (Pertusa-Ortega et al., 2010:313). This complexity in turn enhances a firm's knowledge performance, i.e. the utilization of knowledge for the generation of competitive advantage. This is due to accumulation and mastery of certain skills and abilities of specialists within their specific range of functions (Willem and Buelens, 2006). Moreover, Pertusa-Ortega et al. (2010) suggest that specialization leads to the development of a common understanding and knowledge within subunits, supporting knowledge application, and thus, has a positive effect on what they call “knowledge performance”. Related to firms’ external search, Lane and Lubatkin (1998) suggest that prior related knowledge is conducive to searching and absorbing knowledge from external sources.

Also the literature on organizational learning and the trade-off between exploration and exploitation – i.e. learning in new domains or learning in known domains (March, 1991) – has brought forward similar recommendations. The concept of ambidexterity calls for firms to establish separated structures, which could respectively focus on only one of the two activities in order to improve and sustain firm performance (He and Wong, 2004; Tushman and O’Reilly, 1996). Following Li et al. (2008), the conflict of simultaneous implementation of exploration and exploitation, which is posed to an organization, is dependent on the level of analysis (e.g. firm, project, individual), and thus ambidexterity may also be achieved by specialization within units or teams without strict structural separation (Gibson and Birkinshaw, 2004).

Further, specialization leads to a higher propensity to maintain relationships with external knowledge sources, because specialists possess a higher awareness for the need
to innovate (Hage, 1965; Olson et al., 2005; Ruekert et al., 1985). Rothaermel and Hess (2007:900) find evidence for the major importance of “star scientists” with regard to firms’ external knowledge search, which resemble largely the discussion around the importance of gate-keepers as specialized employees relating to the outside environment (Cohen and Levinthal, 1990; Tushman; 1977; Tushman and Katz, 1980).

Damanpour (1991) and Damanpour and Gopalakrishnan (1998) also find specialization or functional differentiation to be positively related to innovation adoption and performance. This research even suggests that specialization has a higher impact on the later stages of an innovation process than on earlier stages – e.g. specialization positively impacts the exploration stage but even more so the exploitation stage (Damanpour, 1991:580).

However, specialization is also associated with certain drawbacks. An increased generation of domain-specific knowledge due to high levels of specialization involves the development of different languages and views between the various subunits of a firm (Grant, 1996). Hence, specialization leads to decreasing differences within and increasing differences between subunits (Willem and Buelens, 2006). Although specific knowledge within multiple subunits indicates desirable knowledge heterogeneity at the firm-level, it is also associated with increasing structural and mental boundaries inside the firm (Olson et al., 2005; Pertusa-Ortega et al., 2010). An increase of inter-unit boundaries may increase the costs of communication and learning (Colombo and Delmastro, 2008), and thus inhibit knowledge transfer (Willem and Buelens, 2006). Since boundaries between subunits constitute the interfaces across which knowledge is transferred within the company, and each interface bears the risk of potential knowledge loss, a firm may not be able to fully leverage the potential of its external search strategy when specialization is pushed too far (Burkhardt and Küpper, 2009). Garud and Karaswamy (1995:98) speak of the danger of units “hoarding knowledge”. This appears to be a major drawback, since it requires a firm-wide dissemination of knowledge, and thus learning processes between subunits, for the entire firm to benefit from external knowledge integration (Stieglitz and Billinger, 2007).

Van den Bosch et al. (2003) suggest that specialization, thus the division of tasks, equally leads to the division of knowledge. This may result in enormous efforts for re-integrating diverse knowledge-based activities if the respective specialized activities are
part of a greater whole (Van den Bosch et al., 2003:95). And finally, Cohen and Levinthal (1990) argue that specialization undermines innovation performance by reducing diversity, which may be a prerequisite for accessing and absorbing new knowledge. Concerning external search and knowledge integration, low diversity might be indicated by external search being restricted only to specialists, thereby reducing the variety of external search. Though specialization may facilitate external search, it may likewise limit the variety in external knowledge sources, as specialists tend to pursue “narrow” search endeavours (Van den Bosch et al, 2003:95).

Summarizing, specialization can be regarded as supportive to external search, because it leaves external search to specialists (units), who may be more effective in searching external knowledge. Also specialization seems to be conducive to the application of acquired knowledge. Yet, evidence also suggests that specialization leads to a narrow search focus and poses significant strains on the transfer and application of knowledge. Thus, there is inconclusive evidence how specialization effects the relationship between openness and innovation performance. Hence, the following two conflicting hypotheses are stated:

Hypothesis 5a: The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is negatively moderated by organizational specialization

Hypothesis 5b: The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by organizational specialization.

3.2.3 Moderation effects of organizational formalization

Formalization is defined as the degree to which roles, authority relations, instructions, norms and sanctions, ways of communication, and procedures are defined by rules (Child, 1972; Khandwalla, 1977). Hence, the level of formalization reflects the individual firm member's degree of freedom in pursuing organizational tasks and in establishing intra- and inter-firm relationships (Argouslidis and Baltas, 2007; Ruekert et al., 1985). Formalization is often measured by the existence of job descriptions and rule manuals as well as control arrangements (Damanpour, 1991; Miller and Dröge, 1986). Research on the performance effects of formalization has generated contradictory results (Adler and Borys, 1996; Gupta et al., 1986; Lin and Germain, 2003; Pertusa-
Ortega et al., 2010).

The clear definition of rules and the assignment of distinct methods and procedures to functional roles in an organization yield the development of adeptness in a limited area of activities. This in turn results in lower error rates and higher process efficiency (Hage, 1965; Ruekert et al., 1985). Furthermore, formalization codifies best practices and provides organizational memory that facilitates the diffusion of organizational capabilities (for instance, capabilities of how and when to tap into external knowledge sources) as well as the application and the transfer of knowledge (Levitt and March, 1988; Lin and Germain, 2003; Pertusa-Ortega et al., 2010).

On the other hand, the strong emphasis on rules and procedures leads to unchanging patterns of action and reduces process flexibility, as it hinders individuals from deviating from established behavior (Weick, 1979). This might constitute a substantial drawback, since flexibility has been found to facilitate innovation processes (Aiken and Hage, 1971; Burns and Stalker, 1961; Damanpour, 1991). Scholars have argued that, as a consequence of high levels of formalization, firms might risk to ignoring important innovation stimuli (Jansen et al., 2006). On that note, Fredrickson (1986:287) suggested that formalization "[…] has the inherent ability to discourage the pursuit of opportunities". This might be due to the fact that formalization directs attention only towards restricted aspects of the firm's external environment, subsequently reducing the firm's scope of knowledge integration and constraining its exploration efforts (Jansen et al., 2005; Weick, 1979).

Yet, it has also been argued that the existence of norms and explicit procedures facilitates a firm's ability to identify and integrate external knowledge, especially knowledge that is not directly applicable, such as scientific knowledge (Jansen et al., 2005; Vega-Jurado et al., 2008b), and that without formalization, external search and integration would suffer from being “disorganized, sporadic or ineffective” (Okhuysen and Eisenhardt, 2002:383). Also others have associated formalization with positive effects for the utilization of external knowledge. Pertusa-Ortega et al. (2010) see formalization as a means to reduce ambiguity by providing “behavioral directives” (Pertusa-Ortega et al. (2010:312) rather than clear specifications of actions. The reduced ambiguity enhances a firm’s ability to utilize external knowledge more successfully. It is argued that formalization offers the necessary procedures and instruments that
facilitate communication with certain key knowledge sources, such as universities and research laboratories, and endows firms with the competence to access relevant scientific knowledge from these sources (Vega-Jurado et al., 2008a).

However formalization may not only enhance knowledge search, but it may also improve a firm’s capacity to apply the knowledge. Through formalization, “guidelines” for communication and exchange can be established, thereby improving cooperation among employees and units (Cordón-Pozo et al., 2006; Kern, 2006). Cordón-Pozo et al. (2006) further argue that formalization also helps to transfer knowledge between units, as it lays out norms and procedures for engaging in such an exchange. Additionally, formalization was found to help by motivating employees to share explicit and tacit knowledge and by reducing costs associated with knowledge exchange (Dyer and Nobeoka, 2000; Jansen et al., 2005). Formalization is said to be similar to routinization (Feldman and Pentland, 2003), which is argued to enable flexibility (Becker et al., 2005) and reduce ambiguity (Pertusa-Ortega et al., 2010), which in turn may be beneficial for dealing with contingencies, engaging in experimentation, and creating new knowledge (Adler and Borys, 1996).

We conclude that formalization enhances a firms’ ability to broadly search externally, mainly through the reduction of uncertainty and ambiguity, as well as to engage in deep external relations through the means of guidelines for interacting with individual sources, on the one hand. And that, on the other hand, formalization extends its positive implications also to the application of knowledge by means of setting norms, rules, and processes for internal knowledge transfer and application. Thus, the following hypothesis is proposed:

**Hypothesis 6:** The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by organizational formalization.

### 3.2.4 Moderation effects of organizational decentralization

The degree of decentralization reflects the locus of decision-making power: Is decision authority concentrated or rather dispersed in an organization (Pfeffer, 1981)? When decision-making authority is closely held by a few top managers (i.e. concentrated), the organizational structure is referred to as “centralized”. In contrast, “decentralized”
structures exhibit a high degree of participation in decision-making by the members of an organization, since decision rights are delegated to middle- and lower-management levels (Aiken and Hage, 1971). Accordingly, centralization and decentralization are opposite ends of the same scale (Olson et al., 2005).

Scholars of organizational theory have asserted that centralization can have a positive effect on innovation especially under dynamic environmental conditions (Adler and Borys, 1996; Gupta et al., 1986). Top-down directives, for example, offer clear lines of communication and involve unambiguous responsibilities. However, Colombo and Delmastro (2008) identify various sources of organizational failure due to concentrated decision authority. The authors name disadvantages, such as the occurrence of information transmission leaks and delays, the distortions of intra-firm communication, as well as information overload due to narrow communication channels. Due to increased levels of employee participation along all processes, decentralized organizations, on the other hand, tend to generate a higher variety of innovative ideas (Damanpour, 1991; Ullrich and Wieland, 1980). The dispersion of decision rights to middle- and lower-management levels enables the formation of sub coalitions and has a positive effect on the number of possible promoters of innovative projects (Thompson, 1965).

Accordingly, the literature proposes a rather negative relationship between centralization and firm innovativeness, or differently, associates decentralization with more innovative companies (Aiken and Hage, 1971). Emphasizing the positive effects of decentralization, Lichtenthaler and Ernst (2006) find that R&D employees’ attitude towards external knowledge is partly a function of their involvement in corresponding decision-making processes. Furthermore, scholars have suggested that decentralization facilitates knowledge integration and knowledge sharing. Foss, Laursen and Pedersen (2011), for example, investigate how established firms can adapt organizational structure and practices in order to more efficiently leverage user and customer knowledge. The authors argue that decision rights should be collocated with those employees who are best informed about what decision is appropriate in a given context.

Also Ruekert, Walker and Roering (1985) argue that decentralization is likely to be beneficial for innovating companies, since it empowers those employees who are close to the issue to make decisions and to implement them rapidly. Important for the external
search activities of a firm, Cohen and Levinthal (1990) suggest that decentralization increases the number of potential recipients of external knowledge, thus increasing the number of a firm’s interfaces with the external environment. Adding to this, decentralization enhances the adoption of new attitudes and behaviors (Pertusa-Ortega et al. (2010:314), which is especially important for external knowledge use. With respect to knowledge sharing, previous research has suggested that decentralization increases the willingness to share knowledge internally (Gupta and Govindarajan, 2000). Additionally, decentralization broadens internal communication channels and improves the quality of the knowledge that is shared (Sheremata, 2000).

Adding another perspective, broad external search comes along with great requirements for the attention allocation of management (Laursen et al., 2007). Yet, this managerial attention is a scarce good (Ocasio, 1997), and decentralization provides the opportunity for delegation to lower management levels. Further, Laursen and Salter (2006) argue that deep external linkages require specific investments into the relation. Here again, decentralization may be conducive, as investment needs may be best known on levels close to the external source. Beyond that, decentralized structures facilitate the knowledge sharing among subunits and contribute to an increased innovativeness (Van Wijk et al., 2008)

Following this and the above reasoning, the delegation of decision rights has positive implications for a firm’s external knowledge search activities and their performance effects. Thus, we propose:

**Hypothesis 7:** The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by organizational decentralization.

### 3.3 Organizational culture, external search, and innovation performance

This section discusses a firm's organizational culture as a further contingency factor. Organizational culture has frequently been emphasized as being important for innovation performance (De Brentani and Kleinschmidt, 2004; Burns and Stalker, 1961; Lawrence and Lorsch, 1967). In addition, culture has frequently been highlighted as an important factor to implement open innovation successfully (Gassmann et al., 2010; Huizingh, 2011; Lichtenthaler, 2011; Van de Vrande at al., 2010). In this regard,
literature gives special emphasis to aspects such as communication and attitudes towards external knowledge (Chesbrough and Crowther, 2006; Keupp and Gassmann, 2009; Luoma et al., 2010). Yet, overall empirical evidence for the implications of organizational culture remains scarce (Mortara, et al., 2010; Van der Meer, 2007).

The aim of this part of my research is to shed light on how the cultural context that an organization can provide its open innovation initiatives with should be designed in order to be performance enhancing. In other words, this section seeks to establish criteria which make the (organizational) cultural context favorable to reaping the benefits of broad and deep external knowledge search (Figure 7). Building on the literature on market orientation as a cultural trait of organizations (Baker and Sinkula. 1999; Jaworski and Kohli, 1993), this section examines the effects of internal connectedness and open mindedness for the implementation of open innovation as factors determining a cultural openness. Additionally, the attitude prevailing in an organization regarding external knowledge, and as such the existence of the “not-invented-here”-syndrome, is examined.

Figure 7: Research model - openness and the effects of organizational culture
External knowledge integration and organizational culture

Research has shown that firms differ with regard to their potential to profit from open innovation (Lichtenthaler, 2011:89). The application of open innovation requires that firms are capable of utilizing the knowledge they acquire. A crucial aspect in this respect is the “absorptive capacity” of a firm, which refers to the ability of a firm to identify, assimilate, and exploit external knowledge (Cohen and Levinthal, 1990). The literature on open innovation has been frequently emphasizing the need for firms to develop respective capacities (e.g., Chesbrough, 2003a; Chesbrough, 2006a; Dodgson et al., 2006; Lichtenthaler, 2009, 2011).

According to Lane et al. (2006:856), absorptive capacity consists of three distinct stages – the recognition of external knowledge’s value, the assimilation of knowledge, and eventually the application of acquired knowledge. Successful firms are able to identify and evaluate relevant and valuable knowledge, transfer it into internal organizational processes, and combine it with existing internal knowledge for the purpose of exploitation.

Research has shown that the successful conduct of all these stages and absorptive capacity as such, are dependent on the knowledge already present in the acquiring firm and its relatedness to the knowledge acquired (Lane and Lubatkin, 1998). In this understanding, absorptive capacity represents the knowledge base of a firm, and hence the accumulation of prior organizational learning (Cohen and Levinthal, 1990; Lane et al., 2006).

On the other hand, however, absorptive capacity itself is a process of knowledge absorption, and thus a learning process, which in its effectiveness also depends on the organizational context it operates in (Cohen and Levinthal, 1990; Jansen et al., 2005; Lane et al., 2006; Volberda et al. 2010). Thus, we assume here that successful open innovation builds on successful knowledge absorption processes and that firms need to provide a supportive context for the latter (Lichtenthaler and Lichtenthaler, 2009; Lichtenthaler 2011). The factors determining a supportive context for knowledge absorption and transfer processes in turn also constitute the context, and hence contingency factors, for the successful implementation of open innovation.

The organizational context is constituted by formal and informal measures, or differently, the structure and culture of an organization (Foss, 2006). Yet, according to
Lane et al. (2006), only little research exists investigating those contextual factors of a firm’s knowledge absorption process. A recent exception to this is the investigation by Jansen et al. (2005), who examined the influence of several formal and informal coordination mechanisms on the different stages of absorptive capacity. Yet, particular investigations of the implications of organizational culture remain scarce (Volberda et al., 2009:22).

Fundamentally, organizational knowledge absorption processes are processes of organizational learning (Cohen and Levinthal, 1989:569). Central to organizational learning is the transfer and exchange of knowledge and ideas, and thus the communication within the organization (Cohen and Levinthal, 1990:131-132). Without knowledge being shared and transferred, it will remain useless and exert only “limited impact on organizational effectiveness” (Inkpen, 1996:124).

For the exchange of knowledge and ideas, which in turn is necessary for the transfer, integration, and application of knowledge, internal communication is a necessary requisite (Blazevic and Lieve, 2004; Cummings and Teng, 2003). Internal communication and knowledge transfer can be facilitated by organizational mechanisms (Jansen et al., 2005; Van Wijk et al., 2008). Yet, knowledge exchange and communication within a firm are also based in the culture or the informal characteristics of an organization (De Long, 1997; De Long and Fahey, 2000; Gupta et al., 2000; López et al., 2004; Matusik, 2002). The informal context bears great importance for knowledge absorption, as the latter also depends on the existence of a “knowledge-sharing culture” (Daghfous, 2004:21). Or differently, knowledge transfer and sharing can be hampered by an internal tendency or culture to reject knowledge sharing (Sveiby and Simons, 2002:421). Following De Long and Fahey (2000), organizational culture influences knowledge management, and thus knowledge transfer, as it creates the context within which the organization shapes assumptions about knowledge, and the processes of distribution, as well as it constitutes the general context for the social interactions required for the exchange of knowledge.

One feature of the informal context, which is of particular importance for internal knowledge transfer and application, is the internal connectedness of an organization, representing the degree of social integration within a firm (Jansen et al., 2005). Higher degrees of connectedness between units inside a firm improve the opportunities to reach
out to other units and make the exchange of knowledge more efficient (Galunic and Rodan, 1998). Connectedness helps to develop trust and cooperation between units as well as to build a sense of community and a common language (Rowley et al., 2000). Thus, the degree of connectedness between units and individuals facilitates firm-internal knowledge exchange (Jaworski and Kohli, 1993; Rowley et al., 2000).

In addition, also the general sentiment of open mindedness prevalent in an organization facilitates learning and knowledge exchange (Baker and Sinkula, 1999). Innovation requires relinquishing old ways of doing things and learning new ones (March, 1991; Schumpeter, 1942). An organization exhibiting open mindedness is willing to question established views and critically reflect its course of action (Baker and Sinkula, 1999; Porac and Thomas, 1990). Open mindedness is crucial for organizational learning, and thus for the innovation performance of a firm (Baker and Sinkula, 1999).

Further, utilizing open innovation, and thus the absorption of external knowledge, requires a change in the way the organization thinks about external knowledge (Witzemann et al., 2006:27). Lichtenthaler and Ernst (2006:368) constitute that firms need to reduce attitudes an organization may have which lead to a reduction of its potential to benefit from external knowledge. An attitudinal trait which has been referred to oftentimes in this respect is the “not-invented-here”-syndrome (Katz and Allen, 1982; Lichtenthaler and Ernst, 2006). Organizations may suffer from tendencies to reject or to penalize knowledge if it comes from outside the firm, just for the very reason that it comes from outside the firm boundaries (Herzog, 2008; Katz and Allen, 1982; Lichtenthaler and Ernst, 2006). Before the background of open innovation, this tendency or cultural trait gains particular importance (Lichtenthaler and Ernst, 2006). And also for the effectiveness of a firm’s absorptive capacity, the occurrence of NIH should be given attention (Cohen and Levinthal, 1990:133).

The importance of organizational culture and certain cultural traits, such as communication and connectedness, or attitudes regarding external knowledge, new ideas or failure, is also confirmed by research on the features of an innovation-supportive culture. Hurley and Hult (1998:44) emphasize that cultural support for innovation stems from culture being learning oriented. In a review of the literature, Ahmed (1998:36-37) finds open communication, openness to external ideas, the acceptance of failure, and the integration of individuals and units to be relevant for an
innovation-supportive culture. Similarly, Martins and Terblanche (2003:70) find that a culture which positively influences aspects such as team cooperation, open communication, or mistake handling will be supportive for creativity and innovation. Tang (1999:49-50) finds intra-organizational integration, communication, and idea acceptance to be of relevance for innovation-supportive cultures. And McGourty et al., (1996) constitute that especially the promotion of new ideas and collaboration as behavioral dimensions of an organizational culture are important.

In sum, of utmost importance for the success of open innovation is the effective transfer of knowledge throughout all the organizations’ relevant units, which is based on favorable conditions regarding knowledge transfer and communication. These are established by intra-organizational connectedness and open mindedness towards new ideas and failure as well as favorable general attitudes towards external or alien knowledge.

Therefore, it is hypothesized:

**Hypothesis 8:** The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by firms exhibiting internal connectedness.

**Hypothesis 9:** The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by firms exhibiting open mindedness.

**Hypothesis 10:** The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is negatively moderated by firms exhibiting “not-invented-here”-attitudes.

### 3.4 Innovation strategy, external search, and innovation performance

Heeding the calls for an investigation of contingency factors of open innovation (Gassmann, 2006; Gassmann, et al., 2010), this section investigates the effects of firms’ strategic orientation for the performance implications of external knowledge search. The strategic context of firms’ activities is a crucial and influential aspect of firm performance (Burgelman, 1983). Likewise for open innovation, the alignment of firms’ innovation strategy with their external search activities has been proposed as an important lever to increase the performance potential (Lichtenthaler and Ernst, 2009; Lin et al., 2006).
In this chapter, innovation strategy is captured along the dimensions of exploration and exploitation and termed, following He and Wong (2004:484), “explorative innovation strategy” and “exploitative innovation strategy”. The dichotomy of exploration and exploitation has widely been researched as an important driver of firms’ innovation activities and success (He and Wong, 2004; Gupta et al., 2006; Jansen et al., 2006; Sidhu et al., 2007), yet there is little research empirically examining the interplay of firms’ exploitative and explorative innovation strategies and the appropriate design of firms’ external search activities (Harryson et al., 2008). Adding to this, Li et al. (2006:30) and Vanhaverbeke et al. (2006:36) brought exploration and exploitation forward as two important variables to determine a context within which certain independent variables’ influence on dependent variables shall be investigated.

This section addresses the effects of exploration and exploitation for the performance implications of firms’ external search activities, i.e. search breadth and depth (Figure 8). We build on network theory and the distinction between weak and strong ties and assume the effects of search breadth and depth to be similar to the effects of weak and strong ties. It is argued that pursuing an exploration orientation is advantageous for broad external search, whereas deep external search rather fits an exploitation orientation. Both breadth and depth, however, may profit from an ambidextrous external search orientation.

Figure 8: Research model - openness and the effects of innovation strategy
3.4.1 Exploration, exploitation, and ambidexterity

A prominent discussion in management research centres on the distinction of two learning modes or orientations: “exploration” versus “exploitation” (March, 1991) and the assertion that firms need to engage in both modes for securing long-term performance (He and Wong, 2004; Raisch and Birkinshaw, 2008; Raisch et al., 2009; Simsek et al., 2009). This discussion is found in the literatures on organizational change and adaptation, strategic management, organizational learning, and technological innovation (Benner and Tushman, 2003; Burgelman, 1983; Tushman and O’Reilly, 1996; Volberda, 1996).

Exploration is understood as “things captured by terms such as search, variation, risk-taking, experimentation, play, flexibility, discovery, innovation”, and exploitation rather as “such things as refinement, choice, production, efficiency, selection, implementation, execution” (March, 1991:71). Levinthal and March (1993:105) see exploration as “the pursuit of new knowledge, of things which come to be known”, and exploitation as “the use and development of things already known”. Put differently, “exploration” captures activities to search, generate, and apply knowledge which is new and outside a firm’s traditional knowledge domain, whereas “exploitation” refers to the search, generation, and application of knowledge which is already known and part of the firm’s existing knowledge domain.

In general, exploration activities are associated with radical innovations or path-breaking developments, and exploitation is associated with incremental innovations and the development on an existing path or trajectory (Abernathy and Clark, 1985; Atuahene-Gima, 2005; Benner and Tushman, 2003; Levinthal and March 1993). In its original conception, March (1991) just referred to exploration and exploitation as two different learning modes, while stressing the differences in underlying logics, activities, and processes (March, 1991). Others have attempted to narrow the focus subsequently and differentiated exploration-exploitation with regard to technological knowledge and knowledge domains utilized and pursued (Rosenkopf and Nerkar, 2001; Rothaermel and Alexandre, 2009), market and technological knowledge (Benner and Tushman, 2003), or with regard to a distinction between different knowledge search loci and search distances (Sidhu et al., 2007). Exploration and exploitation have been considered as basic learning orientations of a firm (March, 1991), as knowledge search orientations
(Sidhu et al., 2007), or as different innovation types a firm can pursue (Jansen et al., 2006). For this investigation, we utilize the definition of He and Wong (2004) of exploration and exploitation being representations of a firm’s innovation strategy. Consequently, exploration and exploitation are understood as two different specifications of a firm’s strategic orientation with regard to firms’ technological and product innovation (He and Wong, 2004).

Acknowledging the importance of both directions of organizational strategic orientations, the literature likewise agrees that pursuing both simultaneously is as much a performance superior approach as it is a challenge to the organization (He and Wong, 2004; Raisch and Birkinshaw, 2008; Tushman and o’Reilly, 1996). This challenge stems from the different underlying logics, routines, activities, and processes that exploration and exploitation entail (He and Wong, 2004; March, 1991; o’Reilly and Tushman, 2004). At the core of exploration, essentially, is experimentation with new alternatives and the intent to discover something new. The returns are rather uncertain, distant, and often enough negative (March 1991; Rothaermel and Deeds, 2004). The exploration activities of a firm are associated with the adoption of organic structures and loosely coupled organizations and the engagement in “variation, experimentation, and play” (Baum et al., 2000; He and Wong, 2004). On the other hand, exploitation constitutes the opposite on all these counts. It is associated with rather mechanistic and tightly coupled organizational structures and the utilization of “existing routines and experimental refinement”, while its returns are rather predictable, close, and positive (Baum et al., 2000; He and Wong, 2004; March, 1991).

Besides these differences, exploration and exploitation are not completely mutually exclusive. Usually, exploration activities precede a firm’s opportunities to exploit; vice versa, exploitation lays the foundation for exploration (Rothaermel and Deeds, 2004:203). Beyond these apparent synergetic effects, pursuing only one of the two, that is, to focus either solely on exploitation or solely on exploration, has several drawbacks. Firms focussing on exploitation become more adept in a certain area, and are usually inclined to further engage in building that competence and profiting from it (Levinthal and March, 1993). The benefits of exploitation are more immediate and certain (March, 1991), which exacerbates the tendency to build on existing competencies, hence to exploit. Following this, firms face opportunity costs of exploration (Levinthal and
March, 1993), which may be seen as too high. Yet, technology and markets progress and change, and the exclusive reliance on exploiting and improving current competencies and products may eventually threaten the firm with obsolescence, as the product offer and competence on which a firm exploits may become outdated (Leonard-Barton, 1992; Levitt and March, 1988).

Likewise, focusing on exploration exclusively may lead firms to become trapped in what the literature has called “frenzies of experimentation, change, and innovation” (Levinthal and March, 1993:105). As exploration is associated with returns which are more distant and uncertain, and with competency requirements which are new and unknown, failure of exploration activities is likely to occur (March, 1991; Rothaermel and Alexandre, 2009). This may lead firms in turn to engage in ever more exploration to search for successful innovation and compensate for the previous failure (Levinthal and March, 1993:105). But, firms also need to exploit, first in order to generate the resources for exploration, but also to utilize and commercialize what has been explored before (Rothaermel and Deeds, 2004:203; Rothaermel and Alexandre, 2009:762).

In sum, exploration and exploitation constitute two important activities that firms have to engage in for short- and long-term success. Both, however, are in opposition to each other as regards underlying logics, activities, and outcomes (He and Wong, 2004). These tensions of pursuing exploration and exploitation are exacerbated, as firms usually face resource constraints (Bower and Christensen, 1996; Garcia et al., 2003). Thus, firms need to manage the tensions and trade-offs between exploitation and exploration (He and Wong, 2004:482). Research has suggested different approaches in this respect, which range from the temporal separation to a structural separation or the combined or simultaneous pursuit of both exploration and exploitation (Benner and Tushman, 2003; Gibson and Birkinshaw, 2004; Tushman and o’Reilly, 1996). The simultaneous pursuit or the “appropriate balance” of both (March, 1991:71) has also been called “ambidexterity” (He and Wong, 2004:483) and was found to be of positive performance impact (Gibson and Birkinshaw, 2004; He and Wong, 2004).

3.4.2 Exploration, exploitation and the locus of knowledge search

As described before, research has associated exploration and exploitation with great importance for firms’ innovation success and prosperity. To a large extent, though, this
research has focussed on the origins of the trade-off between exploration and exploitation and how firms address this trade-off internally (Raisch et al., 2009:689). Less attention has been given to the locus of organizational knowledge search, and thus the distinction between internal and external knowledge search for exploration and exploitation. An exception to this is the literature on firms’ alliances.

Rosenkopf and Almeida (2003) or Rothaermel (2001) describe how firms use alliances to overcome their internal resource constraints and competency deficiencies and explore through the formation of respective alliances. Other research has investigated the attempts of firms to balance exploration and exploitation through the alliances they maintain. Lavie and Rosenkopf (2006) establish contingencies of firms aiming at balancing exploration and exploitation through different alliances, and Holmqvist (2004) describes how firms focus either on internal exploitation and coalesce with external parties for exploration purposes, or vice versa.

In a more general vein, Koza and Lewin (1998) propose to differentiate alliances of firms with regard to the motivation underlying their establishment, and utilized the exploration or exploitation motive therefor. Exploration alliances endeavour to complement the alliance partners’ resources and competencies to discover something new; and exploitation alliances aim at complementing each other in order to achieve greater profit potential in an existing “business activity” (Koza and Lewin, 1998:256-257). Similarly, Grant and Baden-Fuller (2004:64) differentiate between alliances for mutual learning and alliances for accessing the partners’ competencies and to associate the former with exploration, whereas the latter is linked to exploitation. And also Colombo et al. (2006) propose that alliances per se are not exploratory in nature, but that alliances may also aim at commercialization or at accessing complementary resources, which is considered an exploitative aim. Adding to this, Faems et al. (2005) not only agree with alliances being either exploratory or exploitative in its objectives, but they argue for a portfolio approach regarding firms’ collaboration partners, as these differ with regard to their effectiveness for exploration and exploitation respectively. And finally, going beyond simply stating the existence of alliances with different motivations, Rothaermel and Deeds (2004:216) propose a system of exploration and exploitation alliances in which the former predict “products in development”, which in turn predict the occurrence of exploitation alliances and “products on the market”.
Also research outside the realm of firm alliances has recognized the importance of investigating the locus of knowledge search with an exploration-exploitation lens. Recently, Rosenkopf and Nerkar (2001:289) and also Rothaermel and Alexandre (2009:761-762) argue that both exploration as well as exploitation can be directed outside of the firm’s boundaries as well as inside. Rosenkopf and Nerkar (2001:289) introduce the distinction between organizational boundaries and technological boundaries which can be crossed when searching for knowledge. Crossing technological boundaries here constitutes exploration, whereas staying within technological boundaries resembles exploitation (Rosenkopf and Nerkar, 2001:289). The study suggests the superiority of search crossing organizational boundaries (i.e. external search) for both exploration and exploitation. In an attempt to specify firms’ external search activities, Sidhu et al. (2007) differentiate search into domains along supply-side, demand-side, and geographic spaces. They differentiate these search activities further into local and non-local search, and associate these characteristics with more exploitative and exploratory search, respectively.

To conclude, both the literature on alliances and organizational search know and apply the distinction between exploration and exploitation or acknowledge firms’ external search activities to be either exploratory or exploitative. Thus, knowledge utilization can be distinguished according to where knowledge is searched for and with regard to the search intention or rather with regard to the kind of knowledge searched for. This hints at the relevance of investigating firms’ external search in connection with their exploration and exploitation orientations. Rosenkopf and Nerkar (2001) suggest that in both cases, external search is the superior search option. But, external search can be further specified. Lane et al. (2006:857-858), for instance, constitute a deficiency in clarity about the performance implications of external knowledge with regard to aligning it to (innovation) strategy and exploratory or exploitative search. Applying the distinction of external search into broad and deep external search (Laursen and Salter, 2006), it remains unclear whether broad or deep external knowledge search better suits or is better accompanied by an exploration strategy or an exploitation strategy.

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6 Rosenkopf and Nerkar refer to exploitation as “local exploration”, as they understand exploitation to be an activity where no learning occurs but just the reuse of existing knowledge (Rosenkopf and Nerkar, 2001:289). For a discussion of whether or not learning occurs with exploitation – noting that in this research the former strand of discussion is adopted – refer to Gupta, Smith and Shalley (2006:694).
3.4.3 Search breadth, search depth, and the moderation effects of exploration and exploitation

Following Laursen and Salter (2006), external search can be specified according to the breadth and depth of search activities. Broad search displays the diversity of external sources and inputs and thus the multitude of external connections, whereas deep search designates the frequency of interactions with certain external sources and partners, and thus shows the intensity or strength of external connections (Katila and Ahuja, 2002; Laursen and Salter, 2006). The discussion about the impact of these different characteristics of external search can be linked to the structure and characteristics of firms’ networks, where a similar discussion about the effects of different characteristics of firms’ external relations is known (Bergenholtz, 2011). Of central importance in the latter is the assessment of tie strength, and thus the distinction between weak and strong ties (Fredberg and Piller, 2011; Granovetter, 1973; Hagedoorn et al., 2006; Rowley et al. 2000).

This distinction is based on the differentiation of the frequency with which interactions with external partners occur (Granovetter, 1973:1361). Strong ties encompass recurring interactions with the same partners and oftentimes specific contractual arrangements (Nooteboom and Gilsing, 2004; Rowley et al., 2000). Weak ties, on the other hand, resemble rather infrequent and shallow interactions with changing partners who have lower mutual commitment (Burt, 1992; Dittrich and Duysters, 2007; Granovetter, 1973; Hansen, 1999). Both types of ties were found to be important for firms’ innovation performance. While weak ties offer access to a broad variety of information sources and diverse inputs, which in turn increases the chances for acquiring truly novel information (Krackhardt, 1992; Tiwana, 2008), strong ties draw their advantage from the opportunity to build trust and common understanding in a certain relation, which is conducive to the exchange of more specific, tacit, and fine-grained knowledge (Rowley et al. 2000:371). The establishment of strong ties, hence the frequent engagement with certain external partners, requires investment and a longer-term focus of the involved partners (Bergenholtz, 2011; Larson, 1992). In order to justify these investments and to maximize the likelihood of success, firms may restrict the choice of partners (Hansen, 1999; Nooteboom and Gilsing; 2004; Reagans and McEvily, 2003).

Additionally, the resources necessary to establish strong ties reduce the overall number of relations a firm can engage in. This in turn inhibits the search potential with regard to
truly novel information (Rowley et al., 2000:375). Strong ties oftentimes represent interactions in rather dense, small, and redundant networks of actors already in acquaintance with each other (Hansen 1999; Nooteboom and Gilsing, 2004). Weak ties, on the other hand, are less intensive with regard to mutual investment and offer bridges across the usual field of partners and search domains, thereby offering access to information sources previously unconsidered (Rowley et al., 2000).

Hence, weak ties offer firms diversity of contacts and bridges to non-redundant information sources, while deep ties offer intensity of contacts, trust, and redundancy in relations (Simard and West, 2006; Hagedoorn et al., 2006). In other words, weak ties give access to many external knowledge sources with higher novelty potential, which resembles the effects of broad search strategies, and strong ties allow for longer-term interactions with higher potential for specific knowledge creation and exchange, which resembles the effects of deep search strategies (Laursen and Salter, 2006; Sofka and Grimpe, 2008).

A significant body of research has been investigating the effects of weak and strong ties in connection with firms’ exploration and exploitation activities (Dittrich and Duysters, 2007; Harryson et al., 2008; Phelps, 2010; Rowley et al., 2000). Exploration is associated with the search for new knowledge and ideas outside current domains, and exploitation, on the other hand, with refinement and development within existing domains (Dittrich and Duysters, 2007; March, 1991). The literature is widely in accord that firms pursuing exploration engage in weak tie networks versus firms aiming at exploitation utilize strong tie networks (Dittrich and Duysters, 2007:513).

When searching for truly novel knowledge, thus exploration, firms need to screen a broad array of sources and need to have the flexibility to forego relations in case they prove to be of no use. Thus, a high level of commitment, as in the case of strong ties, is inappropriate at this stage (Dittrich and Duysters, 2007). For exploitation, though, the intention lies on complementing each other’s competences and engaging in longer-term efforts to developing further existing technologies. Hence, strong tie networks oust weak ones here (Dittrich and Duysters, 2007). Schoenmakers and Duysters (2006:250) state in this regard that weak ties are more applicable for the transfer of unrelated knowledge and strong ties rather for the transfer of related knowledge. As described before, in weak tie relationships the interaction is rather shallow and firms are less
familiar with each other. The lower intensity reduces the effort of maintenance and thus allows for broader search scope. Weak tie relations often act as bridges into unrelated (technological) fields (Schoenmakers and Duysters, 2006). If firms are connected by strong ties, they tend to be familiar with each other and stem from similar business and technology fields. Thus, the learning scope in weak tie networks is characterized by breadth and in strong tie networks by depth (Schoenmakers and Duysters, 2006:250).

Rowley et al. (2000:384) find that strong ties are advantageous when exploitation is the major aim and weak ties rather fit with exploration objectives. They argue that appropriate network arrangements differ with the information requirements. Exploitation necessitates deeper and more specific knowledge, which is best transferred through intense relations, hence strong ties. Exploration, though, requires new and unique information, but more importantly, rather broad and general knowledge, which is best acquired through weak ties (Rowley et al., 2000:375). In other words, explorers tend to search broadly, while exploiters rather engage in deep searches (Rowley et al., 2000:374). The theoretical reasoning employed here and the empirical findings are echoed in other literature as well. Phelps (2010:894, 906) concludes that diversity in networks is important for exploration and that diversity is best provided by weak ties. Tiwana (2008:251) constitutes that weak ties are suited for accessing novel information but lack the application potential. This is provided rather by strong ties. Bergenholtz (2011:75) sees weak ties as gateways to new knowledge and associates them with broad search. And finally, Harryson et al. (2008:748-749) differentiate between open networks and tightly coupled networks – the former being networks with mainly weak relationships, the latter with mainly strong relationships. Again, strong ties are best suited for exploration and weak ties do better for an exploitation context (Harryson et al., 2008:750).

However, literature also provided different associations of tie types with exploration and exploitation. For instance, Rowley et al. (2000:384) cannot confirm the negative implications of strong ties for exploration, which were assumed based on the cost-inflicted scope constraints that strong ties may suffer from. Rather, they conclude that strong ties are of particular effectiveness for exploitation and less effective for exploration. And Nooteboom and Gilsing (2004) argue, for instance, that both exploration and exploitation may benefit from stronger ties. In sum however,
theoretical and empirical reasoning indicates that firms’ weak external ties are rather suitable for exploration activities and their strong ties rather suit exploitation activities. Equating weak ties in their effects with search breadth and strong ties with search depth, it is consequently hypothesized:

**Hypothesis 11:** Firms’ external search breadth affects innovation performance more strongly when an explorative innovation strategy is pursued than when an exploitative innovation strategy is pursued.

**Hypothesis 12:** Firms’ external search depth affects innovation performance more strongly when an exploitative innovation strategy is pursued than when an explorative innovation strategy is pursued.

3.4.4 Search breadth, search depth, and the moderation effect of ambidextrous innovation strategy

Exploration and exploitation are both necessary for firms’ long-term performance (Tushman and o’Reilly, 1996). Yet, both display different underlying logics and activities, which poses constraints on their parallel pursuit (He and Wong, 2004). In addition to the tensions arising from combining those different underlying activities, exploration alliances rather employ unspecified and long-term goals, whereas exploitation alliances build on clear and measurable short-term objectives (Koza and Lewin, 2000). However, the simultaneous pursuit – also termed “ambidexterity” - was found to be beneficial for firm performance (He and Wong, 2004; o’ Reilly and Tushman, 2008). Invoking again the literature on firms’ alliances, studies mostly propose to balance exploration and exploitation alliances within a portfolio of alliances that a firm maintains, or to complement internal exploitation (exploration) with external exploration (exploitation) in alliances in order to achieve ambidexterity (Colombo et al., 2006; Lavie and Rosenkopf, 2006; Rothaermel, 2001; Rothaermel and Deeds, 2004).

Yet, given the advantages research associates with a simultaneous pursuit of exploration and exploitation when adopting a firm-internal perspective only (Gibson and Birkinshaw, 2004; He and Wong, 2004) a similar superiority may exist for firms’ external search activities. Besides exhibiting a trade-off relation, exploration and exploitation also complement each other. Koza and Lewin (2000:149) refer to “hybrid alliances” when firms seek to utilize alliances for the joint generation of new knowledge as well as the joint leverage of existing knowledge and capabilities. They state an
example in which joint exploration activities within an alliance build upon the complementation of the partners’ existing competencies, which is exploitation, and thus argue for the advantages of the joint pursuit of exploration and exploitation within an alliance (Koza and Lewin, 2000:149). Rothaermel and Deeds (2004) argue for the joint pursuit, since exploration must be succeeded by exploitation. The generated new knowledge needs to be utilized and commercialized, building on the respective partners competencies. Thus, exploration within an alliance breeds and needs exploitation within the same alliance, and vice versa (Rothaermel and Deeds, 2004:203).

The interaction of exploration and exploitation has also been found to exhibit positive implications for external knowledge search. Rothaermel and Alexandre (2009) find that adopting a balanced approach of exploration and exploitation in firms’ search behavior is performance-superior, as focusing on only one of the two may limit the range of opportunities which firms can identify and implement within or through their external relations.

In a similar vein, Leiponen and Helfat (2010) investigate how the utilization of a multitude of external sources and the pursuit of several innovation objectives influence innovation performance. They argue that utilizing a multitude of external sources as well as pursuing multiple innovation objectives positively influences innovation performance. Further, they argue that both – multiple goals and multiple sources – exhibit positive interaction effects for increasing innovation performance (Leiponen and Helfat, 2010:226). Increasing the amount of sources utilized and goals pursued increases the chances of finding relevant knowledge and ideas (Leiponen and Helfat, 2010). Building on the idea of “sampling models” they argue that the more objectives a firms pursues, the greater the likelihood of finding something which matches a given goal and is successful. Similarly, increasing the amount of sources utilized – given uncertainty about the quality of sources – increases the odds of finding partners and information which will be influential for success. Hence, the logic here is that the more often firms draw from the pool of sources and objectives, the more likely these draws will be leading to eventual success (Leiponen and Helfat, 2010:225).

Further, also the cognitive constraints that managers and firms may suffer from when searching for ideas and knowledge may inhibit innovation success. Firms are likely to search too narrowly and thus forego opportunities of finding valuable knowledge.
Again, by pursuing a multitude of goals and sources, firms can counteract these tendencies (Leiponen and Helfat, 2010:226). These aspects are also echoed by other research stating that greater openness to external knowledge sources and a greater number of objectives increase the odds of finding feasible options for the recombination of old and new knowledge, and thus the opportunities for successful innovation (March, 1991; Katila, 2002; Katila and Ahuja, 2002; Nelson and Winter, 1982; Utterback, 1994).

Leiponen and Helfat (2010:228) build on the concept and measure of ambidexterity for capturing the multitude of innovation objectives. They find both the amount of sources and objectives to be positive for innovation success, yet they cannot constitute any interaction effects of the two. Doganova et al. (2009:21), however, find ambidextrous alliances to be more efficient for product innovation. And also Katila and Ahuja (2002:1186) find that the pursuit of familiar and unfamiliar knowledge makes knowledge search more likely to be productive, and conclude that an intersection of both is most fruitful. Combining exploitation and exploration allows for the application of what is already understood and mastered to newly generated knowledge and solutions and, vice versa, the enrichment of the things already mastered by new knowledge, approaches, and ideas (Doganova et al., 2009:21; Katila and Ahuja; 2002:1191). Or differently, exploitation provides higher certainty, and thus higher probability of innovation (March, 1991), whereas exploration provides greater potential for higher innovativeness of innovation performance. Thus, both in combination should improve the innovation potential of firms’ knowledge search (Doganova et al., 2009).

Consequently, it may be beneficial for firms to set a multitude of innovation objectives for their external search activities, and the combination of exploration and exploitation in their innovation strategy as ambidextrous innovation strategy may supersede “specialized search strategies” (i.e. exploitative or explorative innovation strategy) for the direction of knowledge search. Thus, the following hypotheses are stated:

**Hypothesis 13:** The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by the pursuit of an ambidextrous innovation strategy (i.e. multiple innovation objectives).

**Hypothesis 14:** Firms’ external search (i.e. breadth and depth) affects innovation performance stronger with an ambidextrous innovation strategy than with specialized ones.
3.5 Summary of theoretical discussion and hypotheses

This chapter has introduced the theoretical background of this research. Fourteen hypotheses regarding the impact of search breadth and depth on innovation performance as well as the possible contingency or moderation effects of organizational structure, culture and innovation strategy were posited. In detail, we asked:

**What are the effects of external knowledge search for innovation performance?**

We differentiated firms’ external knowledge search along the dimension of search breadth and search depth. The former simply takes account of the number of external sources being utilized, whereas the latter is the count of all sources with a certain importance to the firm or frequency being used, thus search depth takes account of the number of intense external relations. It was hypothesized that external search, either as broad or as deep external search, enhances firms’ innovation performance but only up to a certain point. Due to costs associated with external search, the performance implications of increasing external search activities were hypothesized to become negative from a certain point onwards. Beyond this, when differentiating the innovation output, it was assumed that search breadth decreases in effectiveness and search depth increases in effectiveness with an increase of the degree of innovativeness, that is from incremental innovation performance to radical innovation performance.

As openness was assumed to have an inverted U-shaped influence on innovation performance, the question arises, by which means this relation can be manipulated to the advantage of the respective firm. Thus, in the further sections we introduced several contingency factors possibly influencing the relation between openness and innovation performance, and asked:

**What are the implications of organizational structure for the relation between external knowledge search and innovation performance?**

In Section 3.2 organizational structure and, as such, the degrees of specialization, formalization, and decentralization were described, arguing that formalization and decentralization would positively affect the potential of firms to benefit from external search, whereas specialization was hypothesized to either exert positive or negative influences on the relation between external knowledge search breadth and depth and innovation performance. By allowing for certain decisions to be taken on lower levels
of the organization, decisions may be made faster. Additionally, decisions may be made before the background of better information about the actual current technological and market needs and possibilities. Altogether, that might contribute to an increase in the potential that firms can realize from their external knowledge search activities. Searching for knowledge outside firm boundaries is an endeavor which entails uncertainties and treading unknown fields or relating to unknown sources. Predefined procedures for the conduct of such activities may alleviate uncertainty and facilitate search and knowledge transfer, hence influence open innovation performance positively. Implementing specialized functions, however, may be of detriment to open innovation performance, as it puts a severe strain on internal knowledge procession, which hampers the performance potential of open innovation eventually.

**What are the implications of organizational culture for the relation between external knowledge search and innovation performance?**

Section 3.3 examined the implications of organizational culture or aspects of the informal organization of a firm. The degree of open mindedness and internal connectedness were posited to be of positive influence through their respective positive effects for internal communication and knowledge transfer. Being open to new ideas and deviating approaches as well as the degree to which employees can approach their colleagues within and across unit boundaries facilitates the exchange of new knowledge and ideas, and thus may strengthen the potential that firms can draw from external knowledge search. The existence of negative attitudes towards external knowledge, though, influences firms’ potential benefits from openness negatively.

**What are the implications of innovation strategy for the relation between external knowledge search and innovation performance?**

In the fourth section of Chapter 3, the interaction of external search and innovation strategy was discussed. It was hypothesized, for instance, that firms profit more from broad external search when adopting an exploration-focused innovation strategy, while on the other hand, deep external search would be facilitated by the adoption of an exploitation-focused innovation strategy. As exploration intends to leave traditional ways of doing things and to find truly new ideas and solutions, broad knowledge search may be the better option to do so, as only via broad search efforts are firms able to screen a broad array of different knowledge sources efficiently. Deep search relations,
however, profit more from the focus being on exploitation. Developing existing offerings and approaches further requires specific knowledge and experiences and perhaps longer-term efforts. All this is better provided or supported by intense search relations. The pursuit of an ambidextrous innovation strategy, that is, the pursuit of both exploration and exploitation at the same time and in a balanced way, was hypothesized to be performance superior to the adoption of either solely an exploration- or exploitation-oriented innovation strategy. The pursuit of several and diverse innovation aims or goals facilitates the success of firms’ search efforts, as it becomes more likely that appropriate ideas or solutions can be found or, knowledge found matches organizational innovation objectives.

All the proposed hypotheses are presented in a comprehensive overview in Table 1.

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Hypotheses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RQ 1</strong></td>
<td>External knowledge search strategies and innovation performance</td>
</tr>
<tr>
<td>1</td>
<td>External search breadth exhibits a curvilinear relationship (taking an inverted U-shape) to innovation performance.</td>
</tr>
<tr>
<td>2</td>
<td>External search depth exhibits a curvilinear relationship (taking an inverted U-shape) to innovation performance.</td>
</tr>
<tr>
<td><strong>RQ 2</strong></td>
<td>External knowledge search strategies and degrees of innovativeness</td>
</tr>
<tr>
<td>3</td>
<td>The more radical the innovation, the less effective external search breadth will be in influencing innovative performance.</td>
</tr>
<tr>
<td>4</td>
<td>The more radical the innovation the more effective external search depth will be in influencing innovative performance.</td>
</tr>
<tr>
<td><strong>RQ 3a</strong></td>
<td>Organizational structures, external search, and innovation performance</td>
</tr>
<tr>
<td>5a</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is negatively moderated by organizational specialization.</td>
</tr>
<tr>
<td>5b</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by organizational specialization.</td>
</tr>
<tr>
<td>6</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by organizational formalization.</td>
</tr>
<tr>
<td>7</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by organizational decentralization.</td>
</tr>
<tr>
<td>RQ 3b</td>
<td>Organizational culture, external search, and innovation performance</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by firms exhibiting internal connectedness.</td>
</tr>
<tr>
<td>9</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by firms exhibiting open mindedness.</td>
</tr>
<tr>
<td>10</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is negatively moderated by firms exhibiting “not-invented-here”-attitudes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RQ 3c</th>
<th>Organizational strategy, external search, and innovation performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Firms’ external search breadth affects innovation performance more strongly when an explorative innovation strategy is pursued than when an exploitative innovation strategy is pursued.</td>
</tr>
<tr>
<td>12</td>
<td>Firms’ external search depth affects innovation performance more strongly when an exploitative innovation strategy is pursued than when an explorative innovation strategy is pursued.</td>
</tr>
<tr>
<td>13</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by the pursuit of an ambidextrous innovation strategy (i.e. multiple innovation objectives).</td>
</tr>
<tr>
<td>14</td>
<td>Firms’ external search (i.e. breadth and depth) affects innovation performance stronger with an ambidextrous innovation strategy than with specialized ones.</td>
</tr>
</tbody>
</table>

Table 1: Summary of proposed hypotheses
4 Empirical strategy

The following chapter describes the empirical strategy used to test the hypotheses and is organized as follows. First, the data collection and sample description are presented. Following this, the measures for the variables are presented, and the methods applied for investigating the hypothesized relations will be briefly discussed.

4.1 Data collection and sample description

The empirical part of this analysis is based on cross-sectional data from the RWTH-Innovationsmonitor, a survey which was conducted by the RWTH Technology and Innovation Management Group in 2010. The study aimed at the identification of management practices that increase firm’s innovation performance. In particular, the survey sought to generate insights into the current state of firms’ management practices for innovation management and external knowledge search.

As source for the basic survey population the Amadeus database was used to preselect a sample of firms. Amadeus is a commercial database providing financial and firm-level information on over 10 million privately and publicly owned firms across Europe (Bureau van Dijk, 2010). The basic sample selected from Amadeus contained a total of 3,709 firms from the German manufacturing sector. Additionally, we only selected firms for which we could obtain data regarding financial performance, and other criteria through the Amadeus database. The selected firms were contacted via telephone in order to identify a contact person responsible for innovation-related activities and with a good overview of the respective firm’s organization and strategy (e.g. head of R&D departments or leading innovation managers). Managers who were willing to participate received personalized emails containing a link leading to the 7-page online questionnaire of the RWTH-Innovationsmonitor.

Relying on single informants is justified by the fact that the questions in our survey concern strategic issues, and thus require a good and thorough picture of a company’s activities. Usually this requires targeting respondents on higher management levels. However, common method bias may be a concern. To alleviate this concern, we employed measures as proposed by Podsakoff at al. (2003). We assured absolute anonymity regarding the answers and information provided. Further, the survey
instrument was generated very carefully in order to ensure utmost precision in the questions. This means, we adapted measures from existing literature and pre-tested these and the whole survey comprehensively and repeatedly on a small sample of innovation management practitioners. Additionally, we motivated the respondents to answer as accurately as possible by the option of receiving a benchmark report (Rothaermel and Alexandre, 2009), and we accompanied the survey by an official university cover letter.

The major part of the online questionnaire is based on the questions and measures used in the Eurostat Community Innovation Survey (CIS), described in the Organization for Economic Cooperation and Development’s (OECD) Oslo Manual (OECD, 2005). The CIS questionnaire has a long tradition in innovation management literature and its measures have been extensively pretested and used in multiple other previous studies (Cassiman and Veugelers, 2006; Laursen and Salter, 2006; Leiponen and Helfat, 2010). We hence assume a very high reliability and validity of these measures. Moreover, compared to traditional measures of innovation performance (e.g. the analysis of patent citation data), CIS measures are gathering information on innovation activity in a “subject-oriented” way (Laursen, 2011:717) by asking respondents about the innovation output of their firm. This is seen as complementary way to traditional measures to elicit information about innovation performance. For example, besides the fact that not all innovations are necessarily patented, patent data analysis rather offers a proxy for firms’ appropriability strategy than for their innovation performance (Laursen and Salter, 2006). In contrast, CIS measures indicate whether firms have actually been able to benefit from their innovation activities. Firms are asked to disclose information on the share of revenue that they ascribe to innovations with different degrees of novelty.

Further, the CIS questionnaire consists of questions regarding a firm’s reliance on external partners and knowledge sources (by means of importance-weighted measures) as well as a firm’s R&D investments and the employment of distinct innovation practices.

Measures of the RWTH-Innovationsmonitor that were not directly applicable from the CIS survey instrument were adapted from existing scales after reviewing the literature on organizational structure, culture, and strategy and external knowledge search and innovation performance. Before sending out the survey, we pre-tested the questionnaire
with the help of a group of managers from innovation management backgrounds. The feedback was used to adapt the instrument and thus establish a better understanding of the survey and increase the content validity.

After closing the data gathering process, 384 replies were received. To increase the response rate, a reminder e-mail was sent out three weeks after the initial mailing was initially sent. This was accompanied by follow-up phone calls to the firms which had initially indicated willingness to participate in the survey but had not responded up to that point. A final reminder e-mail was sent out a few weeks after that.7

In this research we use subsets of 370 and 365 firms, respectively. These derived after adjusting for reported innovation activities and missing values in the respective measures of concern, and indicate a response rate of values between 10% and 9.8%. As we aimed our survey mostly at respondents from higher management levels, a relatively lower response rate is acceptable. For online surveys, a response rate of around 10% is usually regarded as sufficiently acceptable (Klassen and Jacobs, 2001: 724).

Still, the fact that a great amount of firms did not reply to our survey leaves questions about the representativeness of our sample for the original population and a possible non-response bias. This can be examined by a comparison of variables which are known for the base population and the sample as well as a comparison of variables between late and early respondents, respectively. After generating dummy variables for sample versus non-sample and late versus early respondent firms, we compared firms by regressing the dummy variables on certain demographic and model variables. Firms in the sample and firms from the initial population were compared with regard to their age, size in terms of assets and employees, their average revenues, and average profit. Additionally, we examined differences of late and early responding firms with regard to certain model variables. By and large, no appreciable differences were detectable. The comparison did not reveal major concerns about the representativeness and non-response bias. Only with regard to their size did firms in the sample show significant differences. The sample contains larger firms on average than the overall population.8

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7 The survey and the invitation letters can be found in Appendices 1 and 2.
8 With regard to firm size, Bianchi et al. (2011) assert that large firms are more advanced in their adoption of open innovation strategies than small- and medium-sized firms. Hence, the presence of rather larger
The breadth dimension slightly differs when comparing late respondents and early respondents. Also, there are slight differences between early and late respondents regarding the strategy dimensions of our investigation. Late respondents have slightly higher breadth values than early respondents as well as slightly higher values for exploration and exploitation.\(^9\)

All survey questions regarding organizational practices refer to the average of a three-year period from 2007 to 2009. The innovation outcomes were required to be evaluated only for the last year of that period. By doing so, we attempted to temporally separate the independent and the dependent variables in order to account for time lags between innovation activities and innovation outcomes. This also adds to overcoming potential common method bias concerns (Rothaermel and Alexandre, 2009).

The information from the survey provides some general insights into the characteristics of the sample’s firms (Table 2). Firms in the sample are from six different fields of the German production sector. As expectable, against the background of the structure of the German economy, the machinery and vehicle construction branch is represented the strongest in our sample. Next is the metal manufacturing industry and firms manufacturing electronic products. On average, firms in the sample have been roughly 37 years in business and employ around 480 people. It is noteworthy however, that the standard deviations show significant magnitudes.

\(^9\) The tables for the respective analyses can be found in Appendix 3.
<table>
<thead>
<tr>
<th>Industry</th>
<th>No. of firms</th>
<th>Share of total sample</th>
<th>Age in years</th>
<th>SD Age</th>
<th>Size in employees</th>
<th>SD Size</th>
<th>Total assets (in Mio. Euro)</th>
<th>SD assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery and vehicle construction</td>
<td>118</td>
<td>31.9%</td>
<td>34.08</td>
<td>36.6</td>
<td>423.24</td>
<td>673.05</td>
<td>73540.05</td>
<td>148178.36</td>
</tr>
<tr>
<td>Metal processing manufacturing</td>
<td>72</td>
<td>19.5%</td>
<td>34.43</td>
<td>36.58</td>
<td>551.5</td>
<td>1391.95</td>
<td>94607.89</td>
<td>258942.11</td>
</tr>
<tr>
<td>Manufacture of electronic products</td>
<td>65</td>
<td>17.6%</td>
<td>31</td>
<td>30.26</td>
<td>518.12</td>
<td>983.17</td>
<td>124797.38</td>
<td>340382.59</td>
</tr>
<tr>
<td>Manufacture of chemical, pharmaceutical, medical products</td>
<td>28</td>
<td>7.6%</td>
<td>45.79</td>
<td>46.69</td>
<td>823.1</td>
<td>1770.24</td>
<td>147623.61</td>
<td>246873.53</td>
</tr>
<tr>
<td>Miscellaneous finished goods</td>
<td>34</td>
<td>9.2%</td>
<td>43.74</td>
<td>40.44</td>
<td>396</td>
<td>949.59</td>
<td>37324.13</td>
<td>49553.45</td>
</tr>
<tr>
<td>Miscellaneous half-finished goods</td>
<td>53</td>
<td>14.3%</td>
<td>36.17</td>
<td>37.48</td>
<td>330.54</td>
<td>454.9</td>
<td>50100.49</td>
<td>74374.17</td>
</tr>
<tr>
<td>Total</td>
<td>370</td>
<td>100%</td>
<td>35.68</td>
<td>36.93</td>
<td>479.35</td>
<td>1018.95</td>
<td>85540.72</td>
<td>215363.33</td>
</tr>
</tbody>
</table>

Table 2: Sample description by industry - general firm characteristics

Beyond this, Table 3 provides information on the innovation activities and performance of the firms in the present sample. On average, firms generated a rather high share of their current turnover from recent innovations. As one could expect, incremental innovations occur more often, likewise firms generate larger shares of their turnover from incremental innovations – in our sample on average 23%. However, also radical innovations contribute, with an average 15%, a fairly large share to current turnovers. Looking at this on an industry level, one can see that the most innovative firms can be found in the electronic products sector, while the lowest innovation rates are to be found in the metal processing industry.

The electronics industry derives almost double the share of turnover from incremental than from radical innovation. This difference, or imbalance, is by far not so pronounced in the other industries. Looking at the electronics industry again, one can see that firms in this subsample spend on average almost 9% of their revenues on (internal) R&D and employ around 170 people in their R&D units. This is considerably more than the overall averages which lay around 4% and 70, respectively. Thus, this may be an explanation for this industry’s high innovation performance. On external R&D activities, however, firms spend rather little. The average is here around 1% for the whole sample. A notable exception is the chemical and pharmaceutical industry. Acknowledging that this industry also has the second highest amount of R&D employees, the reason for the high innovative performance may also be found in their high expenditure related to external R&D. To note, this industry also has the highest score for search depth, which reflects intense relations with external sources. Now,
research has long shown that particularly the chemical and pharmaceutical industry engages in research and development with external partners in the form of alliances and other modes (Rothaermel, 2001). Also, recent developments around open innovation platforms (e.g. Innocentive) took their departure in the pharmaceutical industry.

Turning to firms’ openness, one can see that firms have adopted the idea of opening innovation processes for outside knowledge. On average, firms utilize 7.8 external sources, while the individual industries’ values do not differ much. Also in line with prior reasoning, the values for search depth are roughly the half as for breadth – on average, firms engage with around 5 sources intensively. Also here, there are no notable differences between the industries. This provides an interesting insight. As firms do not differ much with regard to their exposure to or utilization of external knowledge sources, yet show differences with regard to their innovation performance, the reasons may be found elsewhere than only in the application of open innovation. One has to acknowledge, that reasons may be found in the different market conditions of the respective industries as well as in different underlying technology bases and their respective complexity or innovation proneness, or the alignment of external search with internal resources, such as R&D spending and R&D personnel. Yet, reasons may also be found in differences that industries and firms exhibit with regard to their organization of innovation and knowledge search-related activities.
<table>
<thead>
<tr>
<th>Industry</th>
<th>No. of firms</th>
<th>Average percentage of firms revenues from radical innovations</th>
<th>SD</th>
<th>Average percentage of firms revenues from incremental innovations</th>
<th>SD</th>
<th>Average # R&amp;D employees</th>
<th>SD</th>
<th>Average expenditure internal R&amp;D as percentage of sales</th>
<th>SD</th>
<th>Average expenditure external R&amp;D as percentage of sales</th>
<th>SD</th>
<th>Breadth mean</th>
<th>SD</th>
<th>Depth mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery and vehicle construction</td>
<td>118.00</td>
<td>16.67</td>
<td>17.98</td>
<td>26.36</td>
<td>24.32</td>
<td>89.00</td>
<td>603.82</td>
<td>3.78</td>
<td>4.17</td>
<td>0.59</td>
<td>1.34</td>
<td>7.93</td>
<td>1.95</td>
<td>4.98</td>
<td>2.51</td>
</tr>
<tr>
<td>Metal processing manufacturing</td>
<td>72.00</td>
<td>10.70</td>
<td>13.81</td>
<td>15.72</td>
<td>20.11</td>
<td>21.99</td>
<td>86.42</td>
<td>3.39</td>
<td>11.85</td>
<td>0.76</td>
<td>1.54</td>
<td>7.70</td>
<td>2.12</td>
<td>4.43</td>
<td>2.47</td>
</tr>
<tr>
<td>Manufacture of electronic products</td>
<td>65.00</td>
<td>19.83</td>
<td>17.96</td>
<td>30.94</td>
<td>22.43</td>
<td>169.94</td>
<td>543.13</td>
<td>8.83</td>
<td>12.03</td>
<td>0.90</td>
<td>1.59</td>
<td>8.07</td>
<td>1.67</td>
<td>5.06</td>
<td>2.29</td>
</tr>
<tr>
<td>Manufacture of chemical, pharmaceutical, and</td>
<td>28.00</td>
<td>16.46</td>
<td>17.70</td>
<td>17.18</td>
<td>16.04</td>
<td>61.14</td>
<td>122.25</td>
<td>4.03</td>
<td>5.87</td>
<td>3.01</td>
<td>13.17</td>
<td>8.03</td>
<td>1.77</td>
<td>5.21</td>
<td>2.62</td>
</tr>
<tr>
<td>Miscellaneous finished goods</td>
<td>34.00</td>
<td>17.88</td>
<td>18.42</td>
<td>28.32</td>
<td>21.35</td>
<td>18.21</td>
<td>51.70</td>
<td>3.32</td>
<td>4.54</td>
<td>1.12</td>
<td>1.87</td>
<td>7.38</td>
<td>2.33</td>
<td>4.44</td>
<td>2.40</td>
</tr>
<tr>
<td>Miscellaneous half-finished goods</td>
<td>53.00</td>
<td>9.91</td>
<td>13.08</td>
<td>18.02</td>
<td>18.83</td>
<td>11.45</td>
<td>27.50</td>
<td>2.48</td>
<td>2.90</td>
<td>0.71</td>
<td>1.19</td>
<td>8.03</td>
<td>1.56</td>
<td>4.86</td>
<td>2.29</td>
</tr>
<tr>
<td>Total</td>
<td>370.00</td>
<td>15.19</td>
<td>16.90</td>
<td>23.38</td>
<td>22.27</td>
<td>70.46</td>
<td>415.58</td>
<td>4.38</td>
<td>8.22</td>
<td>0.93</td>
<td>3.88</td>
<td>7.88</td>
<td>1.91</td>
<td>4.84</td>
<td>2.43</td>
</tr>
</tbody>
</table>

Table 3: Sample description by industry - innovation-related firm characteristics
4.2 Measures

Below, the measurement instruments for the relevant variables of this study are discussed. For measurement purposes, this study draws from existing scales for the respective variables. First, the measure for the dependent variable which is used in this study is described. Following, the two independent variables external search breadth and external search depth are introduced. This is followed by the discussion of the moderator variables for all three contingency analyses – organizational design, organizational culture, and innovation strategy. The section concludes with the explanation of the control variables applied.\(^\text{10}\)

**Dependent Variable**

Innovation Performance

To account for a firm’s innovation success, we rely on self-reported measures and use four proxies that aim at reflecting the different degrees of novelty of a firm’s product innovations, as they are also used in the CIS instruments. All these questions refer to the fraction of a firm’s turnover stemming from the respective innovation type. First, respondents were asked to provide the proportion of turnover in the year 2009 that was due to products that had been newly newly to the market (i.e. with the firm being the first to introduce the innovation on its market, which does not necessarily have to be the world market) during the period 2007-2009. Second, respondents were asked to state the percentage of turnover generated by products introduced that were new to the firm but not new to the market. The third question aimed at the proportion of turnover pertaining to products that had been significantly improved. In the last question of this section, respondents were asked to estimate the fraction of the firm’s turnover relating to unchanged products (indicating non-innovative products).

We refer to a product as an incremental innovation when it has been significantly improved, whereas we consider a product to be a radical innovation when it is either new to the market or new to the firm. Thus, we generate one variable as a proxy for both incremental and radical innovation performance, respectively. The variable IMPR reflects incremental innovation performance, and the variable NEW indicates radical

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\(^{10}\) An overview of the measures applied in this research can be found in Appendix 4.
innovation performance, being the aggregated shares of turnover from products *new to the market* and products *new to the firm*. Moreover, we consider the overall innovation performance of a firm to be the total share of turnover pertaining to incremental as well as to radical innovations. Thus, we generate the variable $\text{INN} (= \text{NEW} + \text{IMPR})$ as a proxy for overall innovation performance of the firm.

**Independent Variables**

**External Search Breadth**

Following Laursen and Salter (2006), external search breadth ($\text{Breadth}$) is defined as the number of different types of external knowledge sources that a firm uses in its innovation activities. The RWTH-Innovationsmonitor contains a list of 10 possible knowledge sources. These external sources include, as also shown in Table 4: (1) other internal units (2) suppliers, (3) customers, (4) competitors, (5) private research institutes and commercial laboratories, (6) universities and other higher education institutions, (7) public research institutes, (8) consultants and open innovation intermediaries (e.g. Innocentive, NineSigma etc.), (9) public information (e.g. patent disclosures, industry-specific literature, scientific publications, company reports etc.), (10) official events (e.g. exhibitions and fairs, professional workshops and conferences, trade associations etc.). Even though this list is not fully comprehensive, it covers a large part of a firm’s external environment. Moreover, besides the traditional market-related actors and general institutions operating within the innovation system we refined the list of possible knowledge sources by incorporating external parties, such as open innovation intermediaries that have just recently emerged as considerable actors in the open innovation network (Bahemia and Squire, 2010).

We followed Laursen and Salter (2006) and used survey questions to obtain information about the firms’ openness in terms of external search strategies. To compute external search breadth, managers were asked to indicate the importance of each of the above listed knowledge sources on a 4-point Likert scale ranging from 0 = not important / not used, over 1 = low importance, 2 = important, to 3 = high importance. Accordingly, '0' indicates that the respective type of external knowledge source is not used by the firm, while answers that differ from '0' indicate that the firm draws knowledge from this type of external source. We followed Laursen and Salter (2006) and coded each of the 10
sources as a binary variable (0 = not used and 1 = used). Consequently, the binary variables over all 10 sources were simply added up to create the variable *Breadth*. The score on external search breadth represents the number of different external sources that the innovating firm draws knowledge from. Higher scores of this variable indicate that the firm relies on a highly diverse set of sources and searches its environment very broadly for innovation-related information – thus it is more open (Laursen and Salter, 2006:140).

**External Search Depth**

We used the same question as in the case of search breadth to measure the variable for external search depth (*Depth*). Besides the mere use of different types of external sources, the importance-weighted answers indicate the intensity of the firm's sourcing activities within each of the different channels. Following Laursen and Salter (2006), we constructed another set of binary variables according to the importance a firm ascribes to a knowledge source. Survey responses of 3 = high importance received a value of one, whereas responses of 0 = not important / not used, 1 = low importance or 2 = important received a value of zero. To construct the variable measuring external search depth, we simply summed up the binary values for the 10 sources as mentioned in the previous paragraph. The construct *Depth* thus indicates from how many different external sources a firm intensively draws knowledge in the context of its innovation activities. Higher scores on the variable *Depth* indicate that a firm maintains a great number of ties with external actors, each of which it uses intensively to search for external knowledge.

In order to take account of and analyze the U-shaped relation, respectively the downward-sloping parts of the relation between search breadth and depth and innovation performance, we computed a squared term of both independent variables *Breadth*\(^2\) and *Depth*\(^2\). Together, the two variables Breadth and Depth represent the openness of a firm's search processes and reflect the constitution of the innovating firm's network of external actors (Chiang and Hung, 2010).

Table 4 shows a descriptive overview of the utilization of the different sources by the firms in our sample. Customers are by far the most important external source and hardly any firm in our sample does not utilize customers for innovation input. High importance
also was attributed to any kind of event and sources of information publicly available.
When extending the perspective to the medium importance level, many more sources appear to be relevant. It appears that also suppliers and even competitors are among the important sources. Yet, also universities, research institutions, and other internal units are important sources of innovation-related knowledge. Firms collaborate with a multitude of external sources and regard these sources as crucial, yet only few sources are considered as absolutely indispensable.

<table>
<thead>
<tr>
<th>Knowledge source</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not used</td>
</tr>
<tr>
<td>Other internal units</td>
<td>18</td>
</tr>
<tr>
<td>Suppliers</td>
<td>3</td>
</tr>
<tr>
<td>Customers</td>
<td>2</td>
</tr>
<tr>
<td>Competitors</td>
<td>9</td>
</tr>
<tr>
<td>Private research institutes and commercial laboratories</td>
<td>18</td>
</tr>
<tr>
<td>Universities and other higher education institutions</td>
<td>22</td>
</tr>
<tr>
<td>Public research institutes</td>
<td>31</td>
</tr>
<tr>
<td>Consultants and open innovation intermediaries</td>
<td>55</td>
</tr>
<tr>
<td>Private information</td>
<td>28</td>
</tr>
<tr>
<td>Official events</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 4: Utilization of knowledge sources for innovation purposes (in percentage, N=370)

**Moderator Variables**

Based on the theoretical model introduced in Chapter 3, three contingency dimensions were included in the analysis as possible moderators. First, the dimension organizational structure, represented by the structural variables *specialization*, *formalization*, and *decentralization*, was investigated. Secondly, this study examined the effects of different dimensions of an organizational culture as well as the effects of the innovation strategy a firm has adopted. The measures for all these variables are presented in the following.
Organizational structure

Specialization
The first two structural dimensions, specialization and separation reflect the degree to which departments and employees are functionally or structurally specialized in their activities. Utilizing insights in the literature on firm ambidexterity, we distinguish between specialization as functional differentiation within units and separation as structural differentiation among organizational functions (i.e. marketing, sales, R&D, manufacturing etc.) (Gibson and Birkinshaw, 2004; Volberda 1996, 1998). The former represents a differentiation within the R&D unit, indicating the existence of specialized entities that are in charge of distinct product lines, or the distinction between subunits performing applied research and subunits that focus on basic research. This represents the variable \textit{specialization}. The latter reflects the differentiation of organizational functions within the entire organization and represents the variable \textit{separation}.

Formalization
Based on the measurement instruments proposed in the literature, this study used a single-item measure to assess and determine the extent to which a firm's innovation-related activities are dominated by rules, norms, and detailed job descriptions, thus the degree of \textit{formalization} prevalent in that organization (Desphandé and Zaltman, 1982; Jansen et al., 2005; Pertusa-Ortega et al, 2010).

Decentralization
The third structural variable, \textit{decentralization}, was adapted from Mahr and Kretschmer (2009) and reflects the extent to which decision-making power is concentrated or delegated in an organization. Decentralization was measured as a construct consisting of four items with each item assessing the locus of decision authority in a different innovation-related decision situation. Consequently, respondents were asked to identify the hierarchical level at which each of the respective decisions was usually made. For this purpose, respondents had to rate on a 4-point scale with each value representing a different hierarchical level. The scale included the following values: 1 = team members, 2 = team leader, 3 = head of department, 4 = top management level.
Organizational culture

Open Mindedness

*Open mindedness* is an important feature of an organizational culture supporting communication and knowledge exchange. For this study, the measure for this variable was adapted from Baker and Sinkula (1999), and respondents had to rate how much their organization can be characterized as open to failure and thinking outside existing paths as well as the challenging of management views and perceptions.

Internal Connectedness

Also the connectedness of employees within the organization facilitates internal knowledge procession and was hypothesized in this study as supportive to open innovation. Connectedness represents the degree to which employees are linked up to each other within an organization. This study measures *internal connectedness* based on the measure of Jaworski and Kohli (1993) and asks respondents to assess whether colleagues of different hierarchical levels were easily approachable and whether the exchange of information through informal conversation was a frequent occurrence.

Not-Invented-Here

Thirdly, the attitudes of the organization, and therefore the employees towards external knowledge in general, matter for successful knowledge utilization. This study, then, measures the existence of negative attitudes towards external knowledge with the assessment of the existence of a “not-invented-here”-syndrome. The measure for *NIH* is based on a measure for this phenomenon by Herzog (2008), and asks respondents to assess whether internal knowledge was favored over external knowledge or if only the quality was crucial for the assessment of knowledge.

Innovation Strategy

In order to measure a firm’s innovation strategy, we rely on the distinction of exploration and exploitation in firms’ innovation orientations, and adopt the measurement scale from He and Wong (2004). Exploration captures the importance of entering completely new (product) markets and extending the existing product range,
hence departing from existing innovation fields. Exploitation captures the importance of improving the efficiency of the existing product offering.

The measures **exploration** and **exploitation** focus on how firms distribute resources and attention to different innovation objectives, which either represent an explorative or an exploitative direction (He and Wong, 2004:485). The measure does not refer to the degree of innovativeness or radical versus incremental innovation output, as it intends to capture a firm’s intent when pursuing innovation activities and not the eventual results (He and Wong, 2004:485). For the assignment whether a firm followed an exploration or an exploitation strategy, we carried out a median-split for both the variables. Accordingly, a firm is coded as dominantly following an exploration strategy when its value for exploration was above the median for exploration in the sample. Likewise, a firm is coded as dominantly exploitative in its objectives when its value for exploitation exceeded the median for exploitation of all sample firms (He and Wong, 2004). Firms which obtained scores of 1 for both dummy variables, hence they pursue exploration as well as exploitation objectives similarly dominant in their innovation strategy, were coded as pursuing an **ambidexterity** strategy (He and Wong, 2004). Deviant from this, for the analysis of ambidexterity in Hypothesis 13, we computed a firm’s ambidexterity following Gibson and Birkinshaw (2004), and applied a multiplicative conceptualization of ambidexterity. Hence, ambidexterity is the multiplicative interaction of exploration and exploitation, and firms can pursue lower or higher degrees of ambidexterity.

**Control Variables**

Based on prior empirical research on innovation performance in the management literature, we included a set of control variables that have been found to affect the innovation performance of firms. We controlled for firm size, firm age as well as for different industry affiliations. Moreover, we included four proxies for absorptive capacity, namely the education level of staff, the level of R&D expenditure, the number of R&D employees, and whether or not the firm was engaged in R&D on a frequent level.

**Firm Size and Firm Age**

Previous studies have found innovation performance to be positively affected by size
effects, such as economies of scale and scope (Escribano et al., 2009; Henderson and Cockburn, 1994). Besides the cost benefits associated with that, larger firms have better financial capabilities and larger customer bases, and are therefore more likely to derive high profits from innovation activities. Moreover, firm size has been found to affect a firm’s search behavior (Argyres and Silverman, 2004; Katila and Ahuja, 2002), as well as the propensity of firms to maintain inter-organizational linkages (Knoben and Oerlemans, 2010). Large firms are more likely to devote sufficient amounts of resources to scanning the environment and maintaining external linkages. We controlled for firm size by the number of employees and computed the variable $LN_{EMP}$.

Also firm age has been found to affect innovation performance. Research suggests that although innovative competences seem to improve with firm age, established firms are often failing to adapt to the demands of their technological and market environment (Leonard-Barton, 1992; Sorensen and Stuart, 2000). The misfit between environmental demands and organizational capabilities to innovate may have an effect on the innovation performance of established firms. In contrast, Zimmermann et al. (2009) found that openness is particularly important for young firms. Hence, we controlled for firm age by the years a company has existed through the variable $LN_{AGE}$.

**Absorptive Capacity**

Absorptive capacity is crucial in explaining firm differences in the ability to benefit from collaborations with external partners and from external knowledge integration in particular (Jansen et al., 2005; Lichtenthaler and Lichtenthaler, 2009). Hence, the concept is considered to be crucial for successful inbound open innovation activities (Vanhaverbeke et al., 2007).

Absorptive capacity is said to represent the organizational knowledge base or the existing knowledge a firm possesses, which in turn has positive effects for the ability of firms to acquire and apply external knowledge (Lane and Lubatkin, 1998). Despite its importance, extant literature does not agree on how to capture the concept of absorptive capacity for empirical investigations. Absorptive capacity is said to be a by-product of firms’ R&D spending (Cohen and Levinthal, 1990:129) or that R&D spending contributes to a firm’s knowledge base (Cohen and Levinthal, 1989:570).

Hence, we use a firm’s level of R&D spending (expin) as one proxy for its absorptive capacity. Further, absorptive capacity is a product of the learning within an organization.
and cumulative in nature, thus it is important for a firm to engage in R&D more often than just occasionally. Therefore, we integrated a measure for the frequency of a firm’s R&D activities (rd_perm). Besides these rather organizational level measures for absorptive capacity, research also stresses the importance of individuals in organizational learning, the building of organizational knowledge, and thus absorptive capacity and processes of integrating external knowledge (Cohen and Levinthal, 1990). The capacity of individuals to engage in learning and knowledge integration is one important precondition for a firm’s absorptive capacity. Organizational absorptive capacity is likely to increase with the number of employees who possess high levels of individual absorptive capacity (Cohen and Levinthal, 1990:131). This capacity is strongly influenced by employees’ skills and education level, and other research uses proxies like the number of scientists accordingly (Minbaeva et al., 2003; Zahra and George, 2002). Hence, we further integrated into our proxy measure for a firm’s absorptive capacity measures accounting for the amount of employees with university-level education (acad) as well as for the amount of R&D employees (rd_empl). Based on these four measures, we constructed a compound measure for absorptive capacity as the mean of the sum of the previous single measures after we conducted a logarithmic transformation for each measure except for the binary variable rd_perm. Thus, absorptive capacity is represented by the variable AC, while \[ AC = \text{mean}(\ln rdemp, \ln expin, \text{rd_perm}, \ln acad). \]

**Industry Controls**

Finally, as our data is cross-sectional, we controlled for industry related firm characteristics that influence innovation performance, such as a higher propensity to innovate in different industries. We included six industry controls as dummies for whether a firm is or is not a member of that particular industry. These were identified based on the NACE-codes provided by the Amadeus database. We made a distinction between (1) machinery and vehicle construction (ind1), (2) metal processing manufacturing (ind2), (3) manufacture of electronic products (ind3), (4) manufacture of

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11 It should be noted here that for one analysis we used exclusively the measure for R&D-expenditure \( LN\_EXPIN \) as control instead of absorptive capacity. In other analyses we did not control for absorptive capacity altogether.
chemical, pharmaceutical and medical products (ind4), (5) miscellaneous finished goods (ind5), and (6) miscellaneous half-finished goods (ind6).

4.3 Methods
The scores of all three performance measures (IMPR, NEW, INN), which reflect the percentage of sales from products with different degrees of novelty, range between 0 and 100. Thus, the dependent variables in our model are double censored (having an upper censoring point at the score 100 and a lower censoring point at scores that equal 0; the former is also referred to as “left censoring” while the latter is referred to as “right censoring”). Analyzing such data using ordinary least squares (OLS) regression would lead to biased coefficient estimates (Tobin, 1958). The most appropriate method then to adjust the coefficient estimates and account for the fact that the dependent variable is censored between 0 and 100 is a Tobit analysis (Greene, 2003). The Tobit analysis procedure is based on the assumption of a normal distribution of the dependent variables. Our measures for innovation performance are all skewed to the left, which compromises the underlying assumption of normally distributed residuals in the Tobit model. To account for this departure from the normality assumption, we employed a logarithmic transformation of our dependent variables. This log-transformation resulted in three new dependent variables, overall innovation performance: INN = \ln(1+rev\_inn), incremental innovation performance: IMPR = \ln(1+rev\_impr), and radical innovation performance: NEW = \ln(1+rev\_new). This procedure has also been applied in prior research (e.g. Laursen and Salter, 2006; Oerlemans and Knoben, 2010b).

According to Ai and Norton (2003), the magnitude and direction of interaction effects in non-linear models cannot simply be read from the computed coefficient values. Hence, in order to interpret the interaction effects correctly we follow Greene (2003), who suggests that to be correct on interpretations of coefficients and significances, non-linear interactions have to be plotted. The interaction values are plotted for the moderators’ means (average), for the means plus two standard deviations (very high) and plus one standard deviation (high), as well as for the means minus one standard deviation (low). In addition, also the partial effects of the interactions are plotted. These represent the first derivations of the initial relations. Hence, the first plots of the
analyses display the absolute performance impact of the respective interaction, whereas the second plots always show the success contribution of openness given a certain level of the respective moderator.

In each analysis utilizing this procedure, the first figure shows the actual interaction effect and predicted relation between the independent and dependent variable for different values of the respective moderator (Figure 9). Here it shows that initially, low formalization (slope 1) supersedes higher levels of formalization (slopes 3 and 4), yet with rising openness, higher levels of formalization become performance superior.

![Figure 9: Example plot for overall openness-performance relation by degree of moderator variable](image)

The second figures show the partial effects of the interaction effect for the different values of the respective moderator (Figure 10). It shows that formalization becomes more beneficial with rising openness. Marginal effects make a statement about the increase in innovation performance given a marginal increase of openness and assuming a certain level of the moderator. Slope (3) and (4), for instance, indicate that higher levels of formalization are positive for the increase of openness as they exhibit the highest marginal return levels.
Figure 10: Example plot for marginal openness-performance relation by degree of moderator variable

A third plot (usually to be found in the appendix) shows the significance levels (within the 95% confidence interval) for the partial relations (Figure 11). According to Greene (2003), these plots indicate significance when both the upper and the lower slope are either below or above the zero level – while both slopes being below the zero level indicate negative impacts and both slopes being above the zero level indicates positive impacts. One slope above and one below the zero level indicates non-significance.

Figure 11: Significance analysis for partial effects - low formalization

In the case of Figure 11, at no point both slopes lay above or below the zero line simultaneously. Hence, the slope for low formalization in the partial effects analysis (Figure 10) is not statistically significant. Looking at Figure 12, one can see that
between 2 and 7 sources, both slopes lay above the zero line, thus indicating positive significance of the slope for high formalization in Figure 10 for these parts of the slope.\textsuperscript{12}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure12.png}
\caption{Significance analysis for partial effects - high formalization}
\end{figure}

\textsuperscript{12} All the plots for the respective significance analysis can be found in Appendix 10.
5 Results

This section presents the results of our analysis. Commencing with the results for the impact of search breadth and depth on innovation performance (Section 5.1), the chapter continues to present the results on the moderation effects of organizational structure in Section 5.2, the results for the moderation of organizational culture in Section 5.3 and the results for the analysis of the moderation effects of innovation strategy in Section 5.4. The descriptive statistics and bivariate correlation tables for each respective analysis can be found in Appendix 5.\textsuperscript{13}

5.1 Analysis of external search and innovation performance

This section investigates the effects of firms’ external search activities on innovation performance. We “replicate” the two openness hypotheses originally proposed by Laursen and Salter (2006). This analysis lays the foundation for testing the moderation effects in the subsequent analyses. For this analysis we used a sample of 370 firms and we controlled for the age and size of firms as well as their general ability to utilize external knowledge, i.e. absorptive capacity.

For each external search strategy (i.e. search breadth and search depth), three different models have been estimated. One model for overall innovation performance (INN), one for incremental innovation performance (IMPR), and a third model for radical innovation performance (NEW) as the dependent variable. The results of the respective Tobit regression models can be found in Table 5 (Models I, II, and III) and Table 6 (Models I, II, and III).

Hypothesis 1 states that a firm’s external search breadth exhibits a curvilinear relation (taking an inverted U-shape) with innovation performance. From the results reported in Table 5 strong support for this hypothesis can be found. First, the regression coefficients for Breadth are significant and positive indicating that openness in terms of the amount of external knowledge sources utilized has a positive effect on overall innovation performance of firms (Model I). Second, the squared term of Breadth is negative and significant, which indicates the assumed inverted U-shape external search breadth has

\textsuperscript{13} As indicated by the bivariate correlations in Appendix 5, multicollinearity must not be of major concern.
with regard to overall innovation performance. The relationship stated here also holds for different degrees of innovativeness. External search breadth exhibits the same characteristics with regard to incremental and radical innovation performance (Models II and III).

<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent variables</th>
<th>Independent variables</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>Coefficient</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>INN</td>
<td></td>
<td></td>
<td></td>
<td>IMPR</td>
<td></td>
<td>NEW</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Constant</td>
<td>-1.402</td>
<td>1.028</td>
<td></td>
<td>-2.118**</td>
<td>1.031</td>
<td>-1.369</td>
<td>0.946</td>
</tr>
<tr>
<td>II</td>
<td>LN_AGE</td>
<td>0.028</td>
<td>0.096</td>
<td></td>
<td>0.058</td>
<td>0.090</td>
<td>0.017</td>
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<td></td>
<td>LN_EMP</td>
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<td>0.077</td>
<td></td>
<td>0.075</td>
<td>0.072</td>
<td>0.041</td>
<td>0.071</td>
</tr>
<tr>
<td></td>
<td>AC</td>
<td>3.336***</td>
<td>0.464</td>
<td></td>
<td>2.894***</td>
<td>0.437</td>
<td>2.926***</td>
<td>0.424</td>
</tr>
<tr>
<td></td>
<td>ind1</td>
<td>-0.257</td>
<td>0.417</td>
<td></td>
<td>-0.200</td>
<td>0.390</td>
<td>-0.033</td>
<td>0.380</td>
</tr>
<tr>
<td></td>
<td>ind2</td>
<td>0.056</td>
<td>0.259</td>
<td></td>
<td>0.149</td>
<td>0.243</td>
<td>0.158</td>
<td>0.236</td>
</tr>
<tr>
<td></td>
<td>ind3</td>
<td>-0.571**</td>
<td>0.289</td>
<td></td>
<td>-0.635**</td>
<td>0.273</td>
<td>-0.287</td>
<td>0.264</td>
</tr>
<tr>
<td></td>
<td>ind4</td>
<td>0.287</td>
<td>0.292</td>
<td></td>
<td>0.271</td>
<td>0.274</td>
<td>0.331</td>
<td>0.266</td>
</tr>
<tr>
<td></td>
<td>ind5</td>
<td>-0.209</td>
<td>0.365</td>
<td></td>
<td>-0.283</td>
<td>0.342</td>
<td>0.137</td>
<td>0.332</td>
</tr>
<tr>
<td></td>
<td>ind6</td>
<td>0.621*</td>
<td>0.344</td>
<td></td>
<td>0.630*</td>
<td>0.323</td>
<td>0.610*</td>
<td>0.314</td>
</tr>
<tr>
<td></td>
<td>Breadth</td>
<td>0.641***</td>
<td>0.255</td>
<td></td>
<td>0.635**</td>
<td>0.258</td>
<td>0.499**</td>
<td>0.235</td>
</tr>
<tr>
<td></td>
<td>Breath2</td>
<td>-0.042**</td>
<td>0.018</td>
<td></td>
<td>-0.040**</td>
<td>0.018</td>
<td>-0.032**</td>
<td>0.016</td>
</tr>
</tbody>
</table>

| No of obs. | 370 | 370 | 370 |
| Left-censored obs. | 65  | 79  | 73  |
| Right-censored obs. | 5   | 1   | 0   |
| Log likelihood | -630.334 | -593.234 | -594.188 |
| Chi-square | 113.28*** | 94.38*** | 99.1*** |
| Pseudo R² | 0.08 | 0.07 | 0.07 |

Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 5: Tobit regression, explaining innovation performance with external search breadth

The fact that Breadth and Breadth2 are statistically significant, and that the signs of the estimated coefficients of Breadth and Breadth2 are positive and negative, respectively, corresponds to the predicted inverted U-shaped relationship. These results indicate that, while there are initially positive effects of increasing search diversity, there are decreasing and negative returns when firms use too many external knowledge sources. Yet, the regression results only predict negative returns. It may well be that the downward sloping part of the curve is not significant.

To illustrate these relationships better, we plotted the respective relations for all three types of innovation performance. Figure 13 shows the relation between search breadth and overall innovation performance. What is clearly apparent is the expected U-shape,

14 The figures for the relation between search breadth and incremental and radical innovation performance, respectively, can be found in Appendix 6.
which indicates decreasing returns to increasing external search breadth. The maximum advantage of broad external search appears to be at around 7-8 sources.

To specify this analysis, we investigated the partial effects of external search breadth on innovation performance. That is the marginal return in terms of innovation performance of an increase in search breadth. Figure 14 provides a more specific picture of the effects of greater search breadth. Based on this analysis, we can conclude the tipping point to be at around 7 to 8 sources. The tipping point indicates the level of search breadth up to which an increasing openness still exhibits positive performance implications, though decreasingly so. From this point on, firms generate negative marginal returns to an increase of search breadth. However, the analysis also reveals that the slope in Figure 13 is only significant up to a level of sources being used of around 6. This indicates that our analysis confirms the assumption of decreasing returns to openness, yet negative returns cannot be identified and the downward-sloping part of the curve in Figure 13 can only be predicted, but not concluded to be statistically significant. Altogether, however, these results provide strong support for Hypothesis 1.

Figure 13: Predicted (cumulative) relationship between search breadth and overall innovation performance

15 Again, the effects for both other types of innovation performance look similar, and the respective figures can be found in Appendix 6.
Figure 14: Partial effects of search breadth on overall innovation performance

The results of the Tobit regression analysis testing Hypothesis 2 predicting that also the second dimension of a firm’s external knowledge search activities, external search depth (Depth), is curvilinearly related to innovation performance, can be found in Table 6. The results provide support for the hypothesis, since the coefficients for the squared search intensity variables (Depth and Depth2) are both significant and have the respective signs indicate the predicted curvilinear relation.
Table 6: Tobit regression, explaining innovation performance with external search depth

External search depth has a positive effect on overall innovation performance. But with higher degrees of openness, further increases in search depth lead to reduced overall innovation performance (Model I). Thus, we also accept Hypothesis 2. With regard to the effects of search depth on different innovation performance degrees, our analysis reveals significant implications for incremental innovations, but no significant results for radical innovation performance (Models II and III). As with search breadth, these results are plotted to better illustrate the relationships and analyze the statistical significance of the curve slope.

Figure 15 shows the relation between search depth and overall innovation performance, and again the analysis reveals a curvilinear relationship. For deep search relations, the tipping point appears to be somewhat lower at around 6 sources.

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16 The same applies to the relation between external search depth and incremental innovation performance, for which the figures can be found in Appendix 7.
Again, we performed an additional marginality analysis to attain a clearer picture of the relations. The marginal effects of external search depth can be seen in Figure 16. Up to a level of search depth of around 5 sources, we can identify decreasing returns to openness. The further part of the curve is not significant. Thus, again, we cannot detect negative returns and must acknowledge the downward-sloping part of the curve in Figure 15 as not to be detected statistically significant.

Regarding our control variables, age and size of firms seem to be of no relevance for innovation performance when examining the effects of external search breadth. Our proxy for firms’ internal R&D efforts, a firm’s absorptive capacity (AC), is highly
significant throughout all models without respect to the degree of innovativeness. Firms with higher degrees of absorptive capacity profit more from openness.

In Hypotheses 3 and 4 we assumed differences in the effectiveness of external search breadth and depth depending on the degree of innovativeness of innovation output. Following Laursen and Salter (2006), we assumed external search breadth to become less effective with an increase of the degree of novelty, whereas external search depth was assumed to increase in its effectiveness when the degree of novelty increases. As stated above, external search breadth shows significant effects for both incremental and radical innovation performance, whereas external search depth was found to exhibit significant effects for incremental innovation performance, but not so for radical innovation performance. All the significant effects were in line with our expectation of an inverted U-shape. As a first indication of the effectiveness, one can see that the parameter values for search breadth decrease from INN, to IMPR, and NEW. Likewise, for external search depth, the parameter values increase from INN to IMPR. However, these differences need to be examined for their significance.

Following Laursen and Salter (2006:145), we computed analyses in which the dependent variables are the differences between the radical and incremental innovation performance, and regressed those against breadth and depth, respectively. Based on the estimated coefficients from the Tobit regressions, we also computed two differences: (1) between predicted radical versus predicted incremental innovatives sales as a function of breadth and depth, respectively and (2) between the average marginal effects on radical innovative sales versus incremental innovative sales for breadth and depth, respectively. We assessed the significance of these differences using the Delta method (Greene, 2003), but we could not find any significant differences. However, looking at the analysis of marginal effects again, we can see that the decreasing returns to openness for search breadth start at values of around 2 sources for incremental innovation performance and at values of around 1 for radical innovation performance (Figure 17 and Figure 18).
Thus, external search breadth seems to wear off faster with regard to its impact on innovation performance when the latter is radical than when it is incremental. This lends support to Hypothesis 3 and the assumption of external search breadth being less effective for radical than for incremental innovation performance. External search depth, on the other hand, was found to be of no statistically significant relevance for radical innovation performance, whereas the hypothesis stated external search depth to be more effective for innovation performance when the latter is radical in nature. Also, the parameter values for the impact of search depth on incremental innovation performance is larger than the respective value for radical innovation performance, though not statistically significant.
Following these analyses, we can confirm Hypothesis 3, as we find that external search breadth is consistently important for innovation performance, no matter the degree of novelty, but that for search breadth, the decreasing returns to greater source utilization occur earlier for radical than for incremental innovation performance. However, we cannot confirm that with an increase of innovativeness, search depth would gain in effectiveness. The opposite seems to be true, with a greater degree of novelty, search depth loses significance and only broad external search remains significantly important. Hence, we have to reject Hypothesis 4.

5.2 Analysis of the moderation effects of organizational structure
This chapter presents the analysis of the moderation effects of organizational design dimensions for the relation between firms’ external search activities and their innovation performance. In Hypotheses 5 to 7 we stated the assumed different effects that organizational specialization, formalization, and decentralization may have for influencing the effectiveness of external search. For this we carried out a moderation analysis and entered interaction terms between search breadth and depth and the respective organizational design dimensions into the base model. In this analysis we used a sample of 365 firms and we controlled for the age and size of firms.

Moderation effects of organizational specialization
In Hypotheses 5a and 5b, we suggested that organizational specialization, whether as functional differentiation or as structural differentiation, would influence the inverted U-shaped relation between openness and innovation performance negatively or positively, respectively. We entered the interaction terms (linear and squared) between specialization and openness in terms of external search breadth and depth into the models (Model I for Breadth and Model II for Depth in Table 7). The results show that there is an interaction between search breadth and specialization and no significant interaction for search depth with regard to overall innovation performance. We find that both the linear and the squared interaction term for search breadth are highly significant. However, both terms have signs indicating a rather negative direction of influence. The linear term is negative whereas, the squared term has a positive sign, thus not in line with the inverted U-shape of external search and innovation performance. This would be in line with Hypothesis 5a and we would have to reject Hypothesis 5b, that is,
organizational specialization has negative rather than positive moderation effects for external search and overall innovation performance.

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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 7: Tobit regression, relationship between search breadth and depth and innovation performance - moderation effect of specialization

However, the interpretation of the moderation of non-linear relationships cannot simply be established from the sole regression parameters (Ai and Norton, 2003; Greene, 2003). This is why we plotted the respective relations to better illustrate and to get a clear picture of the actual interaction effects. Figure 19 shows the shapes of the relation

---

17 For the analysis of non-linear moderation effects, we followed the methodological approach by Greene (2003) and plotted the respective relations. See, for background information, Ai and Norton (2003), Greene (2003).
between external search breadth and overall innovation performance differentiated by the levels of specialization. At low levels of external search breadth (i.e. only few external sources), high levels of specialization positively support external search and lead to higher innovation performance compared to lower levels of organizational specialization. Yet, with rising levels of external search breadth, the positive effects of specialization decrease and higher innovation performance can be attained by assuming lower levels of organizational specialization. This turn happens at about 5 sources being used. With even higher levels of external search breadth (around 9 sources being used), high levels of specialization become the preferred choice again. This means that after passing this first search scale threshold, firms with lower levels of specialization benefit more from extended search efforts than highly specialized firms and with the second threshold specialized firms are in favor again. We depicted these relations only for the dependent variable of overall innovation performance, but for incremental and radical innovation performance, the picture is roughly identical.

To further specify the analysis, we conducted an analysis of the marginal effects of openness for higher and lower levels of specialization, respectively. These relations are shown in Figure 20. It shows the curves of the marginal effects of external search breadth differentiated again by the varying degrees of specialization. At any given position of search breadth on any of the curves, the marginal effect indicates whether a
further increase is of benefit or harm with regard to overall innovation performance. Figure 20 shows that at high levels of openness, firms exhibiting high or very high levels of specialization, generate positive marginal returns, whereas firms with lower levels of specialization face negative marginal returns to a further increase in openness. On the other hand, when openness levels are low, firms with medium degrees of specialization generate positive marginal returns, whereas now, firms with higher specialization levels face negative marginal returns. For intermediate levels of search breadth, firms characterized by low levels of specialization generate the highest marginal returns to more openness.

![Figure 20: Level of partial effect of external search breadth for overall innovation performance by degree of specialization](image)

A further analysis of the significance of these relations revealed that the curves are significant in the crucial parts to support the analysis that specialization is of benefit for higher openness levels and rather negative for low openness. Though the curves for low and medium levels of specialization are not statistically significant at high levels of openness, a decrease of the marginal benefits with increasing openness can clearly be detected. Likewise, the positive marginal returns for medium and low specialization at low and medium levels of openness can be identified with statistical significance. The curve for very high specialization is statistically significant at levels of openness between 1 and 4 sources as well as between 8 and 10 sources.

---

18 The plots for the significance examination for this and the following analyses can be found in Appendices 8-10.
The results of the regression analysis for the interaction of external search and organizational specialization with regard to incremental and radical innovation performance can be seen in Table 8. Search breadth and organizational specialization also interact highly significantly for both incremental and radical innovation performance (Models III and V). Again, search depth does not exhibit any significant interaction effect with specialization (Models IV and VI).\textsuperscript{19}

\textsuperscript{19} For this and all the following analyses, we only plotted the relations with regard to overall innovation performance, as the plots for incremental and radical innovation performance do not show substantially different relations and implications.
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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 8: Relationship between search breadth and depth and different degrees of innovation performance - moderation effect of specialization
We further investigated how structural separation as another means of achieving differentiation would affect the inverted U-shaped relation. Table 9 reports the results for overall innovation performance (Models I and II). Again, the interaction effects for external search breadth are significant, yet on a lower level, and have signs indicating rather a negative moderation effect (negative linear term, positive squared term). The result holds for incremental innovation, but there are no significant interactions for radical innovation performance (Table 10, Models III and V). Again, for external search depth (Models II, IV, and VI), no significant interactions could be found.

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Table 9: Tobit regression, relationship between search breadth and depth and innovation performance - moderation effect of separation
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</tbody>
</table>

Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 10: Relationship between search breadth and depth and different degrees of innovation performance - moderation effect of separation
To gain a better understanding of the actual interaction of search breadth with organizational separation, the relation has been plotted again. Figure 21 shows a very similar picture for the effect of separation as a moderator for the relation between search breadth and overall innovation performance. Initially, high separation is advantageous, yet with increasing search breadth, lower separation (i.e. integration of functions and activities) would be preferable. Again, at very high openness levels, a higher level of separation of functions becomes preferable again. For the relation with regard to incremental innovation performance, the picture again looks very similar.

Again we conducted a further analysis of the marginal effects in order to attain more precise results. Figure 22 shows the slopes of the marginal effects of search breadth on innovation performance for different levels of organizational separation. As in the case of specialization, highly separated firms benefit from more openness at high levels of openness, whereas low separated firms face negative returns to more openness when they are already at high openness levels. For lower levels of search breadth, the results show the opposite. Increasing search breadth benefits firms with low or average degrees of separation, while firms with high levels of separation are harmed by increasing their openness levels. The examination of the statistical significance of the slopes in Figure 22 revealed that only the curve for low separation can be detected as significant. Hence,
we can only reliably conclude that low separation benefits firms on low to medium openness levels.  

Figure 22: Level of partial effect of external search breadth for overall innovation performance by degree of separation

Summarizing, the results show no clear dominance of specialization with regard to their positive or negative moderation effects on the link between openness and innovation performance. Rather, the level of openness determines whether specialization is advantageous. Specialization does not exhibit a linear relation with increasing openness. At low openness levels, high specialization is superior to low specialization. Further increasing openness, though, harm specialized firms and benefit less or low specialized firms. For higher levels of openness, lower specialization turns out to be superior. And for very high openness, higher specialization becomes advantageous again. In addition, at levels of high openness, a further increase in openness benefits firms which are rather highly specialized and harms firms with lower levels of specialization. The effects for separation follow a similar pattern. Hence, we can neither fully reject nor accept Hypotheses 5a and 5b.

**Moderation effects of organizational formalization**

Hypothesis 6 suggested that the level of *formalization* of innovation activities positively influences the performance effects of external knowledge search. That is, a firm

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20 Again, the plots for the examination of statistical significance can be found in Appendix 9.
searching broader or deeper externally for knowledge profits from accompanying these search efforts with higher levels of formalization. Our analysis reveals slight evidence for the positive effect of formalization.

Table 11 reports the results of the regression analysis. We entered an interaction term between formalization and search breadth and depth, respectively (Models I and II). The interaction effect of search breadth and formalization is slightly significant (p< 0.1) and the associated signs – linear term positive, squared term negative – indicate a positive moderation effect of organizational formalization.

Also here, as in the case of specialization, our analysis reveals no significant effects for the second dimension of external search, search depth (Models II, IV, and VI). For search breadth, however, the analysis further shows in Table 12 that formalization positively interacts with external search breadth when the dependent variable is “radical innovation performance” (Model V) but shows no significant effects when the dependent variable is “incremental innovation performance” (Model III).

Again, we plotted this relation to gain better insights. Figure 23 shows that with increasing levels of search breadth, high levels of formalization come along with higher overall innovation performance. Whereas, at the beginning – at lower levels of search breadth – lower formalization levels show higher overall innovation performance. Looking at the marginal effects again, Figure 24 shows that at low openness levels, firms with intermediate formalization levels benefit from further openness more than others. Firms with high levels of formalization benefit more than others from more openness at medium openness levels. At very high levels of openness, the plot indicates that low formalizers would profit more from extra openness, yet this slope is not statistically significant. In sum, we conclude that formalization exhibits positive moderation effects, and thus we accept Hypothesis 6.

21 The plots for the significance analyses can be found in Appendix 10.
<table>
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<tr>
<th>Model</th>
<th>Dependent variables</th>
<th>Independent variables</th>
<th>Coefficient I</th>
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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 11: Tobit regression, relationship between search breadth and depth and innovation performance - moderation effect of formalization
Table 12: Relationship between search breadth and depth and different degrees of innovativeness - moderation effect of formalization

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<td>Coefficient</td>
<td>S.E.</td>
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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01
Figure 23: External search breadth, overall innovation performance, and the moderation effect of organizational formalization

Figure 24: Level of partial effect of external search breadth for overall innovation performance by degree of formalization
Moderation effects of organizational decentralization

Hypothesis 7 concerned the effects of *decentralization* for the relation between external search and innovation performance. It was stated that the delegation of decision rights would have a positive influence on the innovation output that firms can attain from external search. The results in Table 13 and Table 14 show no significant results, either for external search breadth or for external search depth as well as no results with regard to a differentiation of innovation outputs. Hence, we cannot accept Hypothesis 7.

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<tr>
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<tr>
<td><strong>Depth2</strong></td>
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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 13: Tobit regression, relationship between search breadth and depth and innovation performance - moderation effect of decentralization
<table>
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<th>Model Independent variables</th>
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<td>NEW</td>
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<td>-0.067 0.093</td>
<td>-0.116 0.091</td>
<td>-0.119 0.091</td>
</tr>
<tr>
<td>LN_EMP</td>
<td>0.192*** 0.075</td>
<td>0.155** 0.074</td>
<td>0.169** 0.073</td>
<td>0.142* 0.073</td>
</tr>
<tr>
<td>ind1</td>
<td>0.023 0.410</td>
<td>-0.039 0.410</td>
<td>0.176 0.402</td>
<td>0.108 0.401</td>
</tr>
<tr>
<td>ind2</td>
<td>0.337 0.256</td>
<td>0.270 0.254</td>
<td>0.309 0.250</td>
<td>0.258 0.248</td>
</tr>
<tr>
<td>ind3</td>
<td>-0.852*** 0.288</td>
<td>-0.862*** 0.287</td>
<td>-0.555** 0.280</td>
<td>-0.564** 0.278</td>
</tr>
<tr>
<td>ind4</td>
<td>0.646** 0.284</td>
<td>0.605** 0.284</td>
<td>0.674** 0.277</td>
<td>0.648** 0.277</td>
</tr>
<tr>
<td>ind5</td>
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<td>-0.231 0.361</td>
<td>0.225 0.355</td>
<td>0.174 0.353</td>
</tr>
<tr>
<td>ind6</td>
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<td>0.514 0.334</td>
<td>0.442 0.331</td>
</tr>
<tr>
<td>Breadth</td>
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<td>0.018 0.809</td>
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<td></td>
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<td>0.015 0.058</td>
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<tr>
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<td>-0.737 1.505</td>
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<td>Breadth x decentralization</td>
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<td>0.335 0.434</td>
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<tr>
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<td>-0.028 0.031</td>
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<td>-0.052 0.052</td>
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<td>365</td>
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<td>73</td>
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<td>Right-censored obs.</td>
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<td>1</td>
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</tr>
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<td>-613.049</td>
<td>-612.514</td>
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<td>74.98***</td>
<td>52.92***</td>
<td>53.98***</td>
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<td>0.05</td>
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</table>

Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 14: Relationship between search breadth and depth and different degrees of innovativeness - moderation effect of decentralization
Finally, the values for the control variables indicate that firm size positively influences innovation performance. This is found for both search strategies and for all different moderator analyses. Size matters for both incremental and radical innovation performance, but larger organizations are slightly more often successful in the generation of incremental innovation (Tables 7-14).

5.3 Analysis of the moderation effects of organizational culture

In a further step we examined specific cultural traits which an organization can exhibit and which are of relevance to the organization’s ability to seek and utilize external knowledge. In Hypotheses 8 to 10 we proposed that firms’ internal connectedness as well as their general attitude of open mindedness facilitate open innovation performance, whereas a negative attitude towards external knowledge (“not-invented-here”) was proposed to have negative consequences for firms’ ability to profit from external knowledge. Utilizing a data set of 365 firms, we employed a moderation analysis and entered interaction terms between search breadth and depth and the respective cultural dimensions into the base model (Aiken and West, 1991; Baron and Kenny, 1986). In this analysis we controlled for the age and size (in terms of employee numbers) of firms as well as firms’ R&D expenditure (as representative of a firm’s absorptive capacity).

In Hypotheses 8 and 9 we suggested that the degree of internal connectedness and the general sentiment climate within an organization of open mindedness would positively influence the inverted U-shaped relation between openness and innovation performance. We entered the interaction terms (linear and squared) between internal connectedness and openness in terms of external search breadth and depth into the models (Model I for Breadth and Model II for Depth in Table 15). The interaction of external search and open mindedness is shown in Table 16 (Models I and II).
### Table 15: Tobit regression, relationship between search breadth and depth and innovation performance - moderation effect of internal connectedness

<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent variables</th>
<th>Independent variables</th>
<th>I</th>
<th>II</th>
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</thead>
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<td>Coefficient</td>
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</tr>
<tr>
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<td>Constant</td>
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</tr>
<tr>
<td></td>
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<td>LN_EMP</td>
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<td>0.076</td>
</tr>
<tr>
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<td>LN_EXPIN</td>
<td>0.640***</td>
<td>0.109</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>-0.116</td>
<td>0.421</td>
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<tr>
<td></td>
<td></td>
<td>ind2</td>
<td>0.064</td>
<td>0.261</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ind3</td>
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<td>0.289</td>
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<td>ind4</td>
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<td>ind5</td>
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<td></td>
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<td>Breadth</td>
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<td></td>
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<td>Depth2 x internal connectedness</td>
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<td>Right-censored obs.</td>
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<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Log likelihood</td>
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<td>-625.682</td>
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<td></td>
<td></td>
<td>Chi-square</td>
<td>94.74***</td>
<td>98.72***</td>
</tr>
<tr>
<td></td>
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<td>Pseudo R²</td>
<td>0.07</td>
<td>0.07</td>
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</tbody>
</table>

Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

The results show that both internal connectedness and open mindedness do not have a significant influence on the relation between external search breadth and depth and overall innovation performance.
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<tr>
<th>Model Dependent variables</th>
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<td>INN</td>
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<tr>
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<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>LN_EXPIN</td>
<td>0.609***</td>
<td>0.108</td>
</tr>
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<tr>
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</tr>
<tr>
<td>ind3</td>
<td>-0.828***</td>
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<tr>
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<td>0.344</td>
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<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>Depth2</td>
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<tr>
<td>Open mindedness</td>
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<td></td>
</tr>
<tr>
<td>Depth x open mindedness</td>
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<tr>
<td>Depth2 x open mindedness</td>
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<tr>
<td>Right-censored obs.</td>
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<td>Pseudo $R^2$</td>
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</tr>
</tbody>
</table>

Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 16: Tobit regression, relationship between search breadth and depth and innovation performance - moderation effect of open mindedness

When differentiating on the innovation output and relating external search to incremental and radical innovation performance, respectively, the results show no significant interactions for open mindedness, but internal connectedness interacts significantly with search breadth when relating to incremental innovation performance (Table 17 and Table 18).
<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent variables</th>
<th>Independent variables</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
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<tbody>
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<td>S.E.</td>
<td>Coefficient</td>
<td>S.E.</td>
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<td>0.149</td>
<td>0.084</td>
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<td>-1.110</td>
<td>1.779</td>
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<td>0.498</td>
</tr>
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<td></td>
<td>Breadth2 x internal connectedness</td>
<td>-0.076**</td>
<td>0.035</td>
<td>-0.022</td>
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<td>0.07</td>
</tr>
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</table>

Two-tailed t-test applied.  * p < 0.10, ** p < 0.05, *** p < 0.01

Table 17: Relationship between search breadth and depth and different degrees of innovativeness - moderation effect of internal connectedness
<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent variables</th>
<th>Independent variables</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>Coefficient</th>
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<th>S.E.</th>
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<td>VI</td>
<td>NEW</td>
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<td>LN_EMP</td>
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<td>0.197***</td>
<td>0.070</td>
<td>0.174**</td>
<td>0.069</td>
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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 18: Relationship between search breadth and depth and different degrees of innovativeness - moderation effect of open mindedness
In order to gain a better understanding of the actual implications of internal connectedness for the relation between search breadth and incremental innovation performance, we need to display the relation slopes graphically. Doing so, we followed Greene (2003) and plotted the respective significant interactions. Figure 25 shows the relation between external search breadth and incremental innovation performance for different levels of internal connectedness. Initially low levels of connectedness within the organization play off higher levels of internal connectedness, yet with increasing openness, firms with very high levels of connectedness generate higher incremental innovation performance. This is confirmed by the analysis of the marginal effects that external search breadth has for innovation performance, given a certain degree of internal connectedness prevalent within the firm, which is shown in Figure 26.

Figure 25: External search breadth, incremental innovation performance, and the moderation effect of internal connectedness

Operating at low levels of external search breadth, firms profit from increasing their openness levels when they show very high levels of internal connectedness, whereas firms with low levels of connectedness among units and employees even generate negative benefits. And only for these levels of openness can a statistically significant conclusion be drawn from our data. The curve for very high connectedness levels is significant within the range of 1.5 to 7 sources and the curve for low connectedness is significant between 1.5 and 3 sources.22

22 The plots for the significance analyses can be found in Appendix 11.
Figure 26: Level of partial effect of external search breadth for incremental innovation performance by degree of internal connectedness

In sum, we can partially support Hypothesis 8, but we find no supporting evidence for Hypothesis 9. This means that we cannot find empirical evidence for the importance that the degree of open mindedness within an organization has for improving a firm’s ability to increase its innovation performance by means of external knowledge search. Yet, the degree of internal connectedness seems to be an important aspect for the successful generation of innovation performance by means of external knowledge acquisition. High levels of connectedness within an organization improve firms’ potential to generate incremental innovation output from externally generated knowledge.

We further investigated how the attitudes of an organization towards external knowledge would affect the inverted U-shaped relation. Therefore, we entered an interaction term between external search breadth and depth, respectively, and the measure for the existence of the “not-invented-here”-syndrome (NIH). Table 19 reports the results for overall innovation performance (Models I and II).
### Table 19: Tobit regression, relationship between search breadth and depth and innovation performance - moderation effect of "not-invented-here"-attitudes

Hypothesis 10 stated that the existence of the “not-invented-here”-syndrome (NIH) has negative implications for the relation between firms’ openness and their innovation performance. The results of our analysis show that the interaction effect of search depth and firms’ external search activities is significant for overall innovation performance (Table 19, Model II). For search breadth, however, no significant implications of a “not-invented-here”-attitude could be detected (Table 19, Model I).

To gain a better understanding of the actual direction of the interaction, the relations have to be plotted (Greene, 2003). Figure 27 shows the shapes of the relation between external search depth and overall innovation performance differentiated by the levels of NIH.
Figure 27: External search depth, overall innovation performance, and the moderation effect of "not-invented-here"-attitudes

The figure shows the dominance of firms exhibiting low levels of NIH, as compared to firms with high and very high levels of NIH almost throughout the whole range of openness. Investigating the marginal effects of search depth, Figure 28 shows that firms with low levels of NIH profit more from an increase in openness when openness levels are high already. At lower levels of openness, firms with high levels of NIH generate higher marginal returns on extra openness. Yet, looking at the statistical significance, we see that only the slopes for high and very high NIH are significant in the range from zero to five sources.\footnote{The plots for the significance analyses can be found in Appendix 12.}
Figure 28: Level of partial effect of external search depth for overall innovation performance by degree of "not-invented-here"-attitudes

After differentiating on the innovation output, search depth shows significant interactions with NIH for incremental and radical innovation performance (Table 20, Models IV and VI). In the case of radical innovation performance, also search breadth exhibits a significant interaction with NIH (Table 20, Model V). These relations were likewise plotted and show a similar picture. Figure 29 shows the plot for search depth and radical innovation performance. Again, low levels of NIH in interaction with external search depth lead to higher innovation performance on average. This also holds true for the case of external search breadth in relation to radical innovation performance, as shown in Figure 30. Again, we conducted an analysis of the marginal effects. In the case of search depth and radical innovation performance, the slope for very high NIH is significant for the range from zero to five sources. The slope for low NIH is significant for the ranges from zero to 1 and seven to ten sources. Similarly in the case of search breadth, the slopes for high and very high NIH show statistical significance in the range from zero to six and one to seven sources, respectively. The slope for low NIH can be detected as significant from zero to two sources.²⁴

²⁴ The plots for the analysis of marginal effects and the respective significance analyses can be found in Appendices 13-15.
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<td>103.9***</td>
<td>89.1***</td>
<td>95.5***</td>
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<tr>
<td></td>
<td>Pseudo R²</td>
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</tbody>
</table>

Two-tailed t-test applied.  * p < 0.10, ** p < 0.05, *** p < 0.01

Table 20: Relationship between search breadth and depth and different degrees of innovativeness - moderation effect of "not-invented-here"-attitudes
Figure 29: External search depth, radical innovation performance, and the moderation effect of "not-invented-here"-attitudes

Figure 30: External search breadth, radical innovation performance, and the moderation effect of "not-invented-here"-attitudes
Regarding the control variables, the values indicate that firm size positively influences innovation performance. This holds for both search strategies and over all different moderator analyses. Size matters for both incremental and radical innovation performance. As expectable, the expenditure of firms for R&D has significant and strong positive implications for firms’ innovation performance (Tables 15-20).

In sum, we cannot support or reject Hypothesis 10 terminally. Negative attitudes towards external knowledge (NIH) seem to pose a problem for firms attempting to benefit from external knowledge search. Particularly so, for the generation of radical innovation output and deep external linkages (i.e. search depth). Here, the “not-invented-here”-syndrome as a trait of an organization’s culture is especially problematic when openness levels are high. Firms profit from further increases only when the level of NIH is low. Yet, the results also show that when openness levels are lower, NIH does not seem to be too problematic after all.

5.4 Analysis of the moderation effects of innovation strategy

Finally, we investigated the contingency effects of innovation strategy for the relation between firms’ external search activities and their innovation performance. In this analysis, we used a sample of 365 firms, and we controlled for the age and size of firms.

For analyzing the impact of innovation strategy for external search, we relied on the distinction between an explorative innovation strategy and an exploitative innovation strategy as well as the simultaneous pursuit of both: an ambidextrous innovation strategy (He and Wong, 2004:484). The objective was to determine (a) whether firms do better and profit more from openness when they pursue a multitude of innovation objectives (i.e. ambidexterity) or rather when they align their external search efforts with a specialized innovation intent (i.e. either exploitation or exploration) and (b), which innovation orientation then suits a broad and a deep external search strategy better.

In Hypotheses 11 and 12 we proposed that search breadth would profit from an exploration orientation rather than an exploitation orientation, and search depth rather from an exploitation focus in innovation strategy. In order to analyze these hypotheses, we generated a sub-sample, which only contained firms which either followed an exploration or an exploitation strategy. Firms which were not able to be identified as
explorer or exploiter, or which followed both innovation orientations, thus which had adopted an ambidextrous innovation orientation were left out of the analysis for Hypotheses 11 and 12. In addition, we computed a dummy variable for the pursuit of an exploration strategy (d-exploration). This dummy variable adopts values of 1 for exploration orientation and 0 for exploitation orientation.\textsuperscript{25} The moderation of the initial relation between search breadth and depth and innovation performance by the dummy variable allows to analyze which effects search breadth and depth have, dependent on the value of the dummy variable, hence either the firms are explorers or exploiters.

Table 21 reports the results for Hypotheses 11 and 12 with regard to overall innovation performance. Search breadth does not show significant interaction with exploration orientation, which indicates that explorers do not benefit significantly more from search breadth than do exploiters (Model I). Thus we find no support for Hypothesis 11, which states that the impact of search breadth would be strengthened by the pursuit of an exploration strategy rather than an exploitation strategy. Looking at search depth (Model II), we find a significant interaction with the dummy variable. However, the coefficient is negative, thus indicating that exploiters profit more from depth than explorers. This supports our hypothesis that the impact of search depth would be facilitated by the pursuit of an exploitation-focused innovation orientation rather than by the pursuit of exploration objectives.

A further analysis of these hypotheses, differentiating innovation performance into radical and incremental innovation, largely confirms the results for search depth. However, the results for the relation between breadth and incremental innovation performance even provide slight evidence that also for breadth, exploiters profit more than explorers.\textsuperscript{26} Altogether, however, it has to be conceded that the evidence for any of the assumed relationships is rather scarce.

\textsuperscript{25} In fact, the value 0 means that firms cannot be coded as explorers. Yet this is the same as if they were coded as exploiters.

\textsuperscript{26} The table for the analyses for incremental and radical innovation performance can be found in Appendix 16.
Table 21: Tobit regression, relationship between search breadth and depth and innovation performance - moderation effect of exploration and exploitation orientation

Hypotheses 13 and 14 proposed that both external search breadth and depth would benefit from an ambidextrous innovation strategy as well as that the pursuit of an ambidextrous focus in innovation strategy would lead to higher innovation performance impact of search breadth and depth than the focus on either exploration or exploitation (Doganova et al., 2009).

Table 22 shows the results for the interaction of external search breadth and depth and ambidextrous innovation strategy, respectively. Both breadth and depth exhibit significant interactions with ambidexterity in relation to overall innovation performance (Models I and II). This largely holds when differentiating the innovation performance into incremental and radical innovation output. Table 23 shows that external search

<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent variables</th>
<th>I</th>
<th>II</th>
</tr>
</thead>
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<tr>
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<tr>
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<td>0.032</td>
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<td>D_Exploration</td>
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<td>Depth x d_exploration</td>
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<tr>
<td>Depth2 x d_exploration</td>
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<td>0.045</td>
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<td>Chi-square</td>
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<tr>
<td>Pseudo R²</td>
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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01
breadth interacts statistically significant with ambidextrous innovation strategy on both performance variables and depth with regard to radical innovation only (Models III – VI).

<table>
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<th>Model</th>
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<td>ind3</td>
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<td>1.066</td>
</tr>
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<td>Breadth2 x ambidexterity</td>
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<td>Ambidexterity</td>
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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 22: Tobit regression, relationship between search breadth and depth and innovation performance - moderation effect of ambidextrous innovation strategy.
### Table 23: Relationship between search breadth and depth and different degrees of innovativeness - moderation effect of ambidextrous innovation strategy

<table>
<thead>
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<th>VI</th>
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<td>Coefficient</td>
<td>S.E.</td>
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<td>0.173**</td>
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<td>-0.065</td>
<td>0.403</td>
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<tr>
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<td>0.284</td>
<td>-0.863**</td>
<td>0.283</td>
</tr>
<tr>
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<td>0.282</td>
<td>0.627**</td>
<td>0.280</td>
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<tr>
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<td>ind5</td>
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<td>0.358</td>
<td>-0.118</td>
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<td>0.498</td>
<td>0.335</td>
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<tr>
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<td>0.355</td>
<td>0.346</td>
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<tr>
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<td>-0.018</td>
<td>0.024</td>
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<td>Breadth x ambidexterity</td>
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<td>-1.732*</td>
<td>0.967</td>
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<td>Breadth2 x ambidexterity</td>
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<td>0.073</td>
<td>0.11585*</td>
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<td>0.141</td>
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<td>-2.279***</td>
<td>0.685</td>
</tr>
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<td>Depth x ambidexterity</td>
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<td>0.347</td>
<td>0.862**</td>
<td>0.342</td>
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<td>Depth2 x ambidexterity</td>
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<td>0.038</td>
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<td>-609.203</td>
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<td>72.66***</td>
<td>47.04***</td>
<td>54.3***</td>
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<td>Pseudo R²</td>
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<td>0.05</td>
<td>0.03</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01
Again, the interpretation of the moderation of non-linear relationships cannot simply be established from the sole regression parameters. That is why we plotted the respective relations to better illustrate and to get a clear picture of the actual interaction effects.

Figure 31 shows the shapes of the relation between external search breadth and overall innovation performance differentiated by the levels of ambidexterity. Initially, at low levels of external search breadth (i.e. only few external sources), high levels of ambidexterity support external search and lead to higher innovation performance compared to lower levels of organizational ambidexterity. Yet, with rising levels of external search breadth, the positive effects of ambidexterity recede and firms exhibiting low ambidexterity levels attain higher innovation performance.

Figure 31: External search breadth, overall innovation performance, and the moderation effect of ambidextrous innovation strategy

We depicted these relations only for the dependent variable of overall innovation performance, but for incremental and radical innovation performance, the picture is roughly identical. In a further step, we analyzed the marginal performance effects of openness, given certain levels of ambidextrous innovation strategy. These relations are shown in Figure 32.

---

27 For the analysis of non-linear moderation effects, we followed the methodological approach of Greene (2003) and plotted the respective relations.
Figure 32 shows the slopes of the marginal effects of external search breadth differentiated by the varying degrees of ambidexterity. At any given position of search breadth on any of the curves, the marginal effect indicates whether a further increase is of benefit or harm with regard to overall innovation performance. Figure 32 shows that firms initially (at low openness levels) profit from increasing external search breadth more with low to average degrees of ambidexterity in their innovation strategy. At very high openness levels, however, a further increase of external source utilization is only sensible with an ambidextrous innovation strategy again (i.e. the pursuit of several and various innovation objectives).  

The same analysis was carried out for the depth dimension of firms’ external search. Figure 33 shows that external search depth initially benefits from lower ambidexterity levels, but that with increasing firms’ openness, the pursuit of multiple innovation goals, hence ambidexterity, becomes the preferred choice.

---

28 The figures for the analyses of statistical significance can be found in Appendices 17 and 18.
This is confirmed by the marginal analysis, which shows that firms profit from increasing their openness levels when they follow ambidextrous innovation orientation. Figure 34 shows that for high and very high ambidexterity firms generate the highest marginal returns on increasing external search depth.²⁹

²⁹ The slopes referred to are the green and violet ones. Only these show statistical significance in the range from zero to five and six sources.
Hypothesis 13 examined whether or not external search is influenced by the adoption or pursuit of an ambidextrous innovation strategy by a firm and which direction this influence would take. Hypothesis 14, in addition, suggests that an ambidextrous innovation strategy plays out the adoption of specialized innovation strategies, i.e. either exploration or exploitation, concerning the effects with regard to facilitating the performance impact of external search breadth and depth. In other word, firms benefit more from openness when adopting an ambidexterity strategy than when they focus on one direction – exploration or exploitation – alone.

For conducting these analyses, we differentiated the sample along the dimensions of exploration, exploitation, and ambidexterity. We generated a sub-sample, which consisted of firms which either were able to be classified as explorers or as exploiters (i.e. adopters of specialized strategies), only. Secondly, we generated a sub-sample with firms able to be classified as adopters of an ambidextrous innovation strategy (i.e. both directions are being pursued simultaneously on a high level) only. Within these samples, we then simply examined the relation between search breadth, search depth, and the different degrees of innovativeness. Table 24 shows the results for the relation between external search breadth and depth and overall innovation performance for the sample of firms with specialized innovation strategies. Here, only the breadth dimension exhibits a significant interaction with innovation performance Model I).
<table>
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</thead>
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<tr>
<td></td>
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<td>LN_EMP</td>
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<td>ind4</td>
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<td>ind5</td>
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<td>ind6</td>
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<td>0.581</td>
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<td></td>
<td>Breadth2</td>
<td>-0.059**</td>
<td>0.029</td>
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<td></td>
<td>Depth</td>
<td></td>
<td>-0.056</td>
</tr>
<tr>
<td></td>
<td>Depth2</td>
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<td></td>
<td>No of obs.</td>
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<td>156</td>
</tr>
<tr>
<td></td>
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<td>29</td>
</tr>
<tr>
<td></td>
<td>Right-censored obs.</td>
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<td>0</td>
</tr>
<tr>
<td></td>
<td>Log likelihood</td>
<td>-273.133</td>
<td>-276.167</td>
</tr>
<tr>
<td></td>
<td>Chi-square</td>
<td>37.82***</td>
<td>31.76***</td>
</tr>
<tr>
<td></td>
<td>Pseudo R²</td>
<td>0.06</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Two-tailed t-test applied.  * p < 0.10, ** p < 0.05, *** p < 0.01

Table 24: Tobit regression, relationship between search breadth and depth and innovation performance - sample specialized strategies

When looking at the same relations within the sample of firms with ambidextrous innovation strategies, one sees that only depth impacts innovation performance significantly (Table 25, Model II). These results also hold after differentiating the innovation performance into incremental and radical innovation performance.  

---

30 The tables for the respective regression analyses can be found in Appendix 19.
<table>
<thead>
<tr>
<th>Model</th>
<th>Dependent variables</th>
<th>Independent variables</th>
<th>Coefficient</th>
<th>S.E.</th>
<th>Coefficient</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>INN</td>
<td>INN</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Constant</strong></td>
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<td>2.639</td>
<td>0.459</td>
<td>0.901</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LN_AGE</strong></td>
<td>-0.066</td>
<td>0.139</td>
<td>-0.094</td>
<td>0.135</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LN_EMP</strong></td>
<td>0.161</td>
<td>0.107</td>
<td>0.131</td>
<td>0.104</td>
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<td></td>
</tr>
<tr>
<td><strong>ind1</strong></td>
<td>0.014</td>
<td>0.696</td>
<td>-0.171</td>
<td>0.678</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ind2</strong></td>
<td>0.523</td>
<td>0.386</td>
<td>0.340</td>
<td>0.376</td>
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</tr>
<tr>
<td><strong>ind3</strong></td>
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<td>0.433</td>
<td>-0.716*</td>
<td>0.416</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ind4</strong></td>
<td>0.427</td>
<td>0.439</td>
<td>0.237</td>
<td>0.429</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ind5</strong></td>
<td>0.767</td>
<td>0.588</td>
<td>0.573</td>
<td>0.570</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ind6</strong></td>
<td>0.771</td>
<td>0.481</td>
<td>0.561</td>
<td>0.457</td>
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</tr>
<tr>
<td><strong>Breadth</strong></td>
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<td></td>
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<tr>
<td><strong>Breadth2</strong></td>
<td>-0.061</td>
<td>0.044</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Depth</strong></td>
<td></td>
<td></td>
<td>0.608**</td>
<td>0.260</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Depth2</strong></td>
<td></td>
<td></td>
<td>-0.037*</td>
<td>0.022</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No of obs.</strong></td>
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<td></td>
<td>137</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Left-censored obs.</strong></td>
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<td>17</td>
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</tr>
<tr>
<td><strong>Right-censored obs.</strong></td>
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<td>5</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Log likelihood</strong></td>
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<td>-229.740</td>
<td></td>
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<td><strong>Chi-square</strong></td>
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<td><strong>Pseudo R²</strong></td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Table 25: Tobit regression, relationship between search breadth and depth and innovation performance - sample ambidextrous strategies

The results show that firms with specialized search strategies rather benefit from searching broadly in their external environment. Firms characterized by the adoption of ambidextrous innovation strategies rather benefit from search depth, hence intense external relations. This is largely in line with the findings concerning Hypothesis 13 above, which found external search breadth to rather benefit from low levels of ambidexterity and search depth to profit from higher ambidexterity levels. This leads us to confirm support for Hypotheses 13 and 14 with regard to external search depth only.

5.5 Summary of hypotheses testing

Summarizing, we find support for the positive yet limited effects of accessing and utilizing external knowledge for innovation performance. We further investigated whether firms are able to align themselves with their external search efforts to be in a
better position to profit from open innovation. This research has posited several structure-, culture-, and strategy-related hypotheses, representing possible management approaches to conducting firms’ search efforts. By large, there is evidence that firms’ management has levers to influence their potential for innovation success from open innovation (Table 26). We will discuss these findings in greater detail in the next chapter.

<table>
<thead>
<tr>
<th># Hypothesis</th>
<th>Supported / not supported</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hypothesis</strong></td>
<td><strong>Hypotheses</strong></td>
</tr>
<tr>
<td>1</td>
<td>External knowledge search strategies and innovation performance</td>
</tr>
<tr>
<td></td>
<td>External search breadth exhibits a curvilinear relationship (taking an inverted U-shape) to innovation performance.</td>
</tr>
<tr>
<td>2</td>
<td>External search depth exhibits a curvilinear relationship (taking an inverted U-shape) to innovation performance.</td>
</tr>
<tr>
<td>3</td>
<td>External knowledge search strategies and degrees of innovativeness</td>
</tr>
<tr>
<td></td>
<td>The more radical the innovation, the less effective external search breadth will be in influencing innovative performance.</td>
</tr>
<tr>
<td>4</td>
<td>The more radical the innovation, the more effective external search depth will be in influencing innovative performance.</td>
</tr>
<tr>
<td>5a</td>
<td>Organizational structures, external search, and innovation performance</td>
</tr>
<tr>
<td></td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is negatively moderated by organizational specialization.</td>
</tr>
<tr>
<td>5b</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by organizational specialization.</td>
</tr>
<tr>
<td>6</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by organizational formalization.</td>
</tr>
<tr>
<td>7</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by organizational decentralization.</td>
</tr>
<tr>
<td>8</td>
<td>Organizational culture, external search, and innovation performance</td>
</tr>
<tr>
<td></td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by firms exhibiting internal connectedness.</td>
</tr>
</tbody>
</table>
The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by firms exhibiting open mindedness.

The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is negatively moderated by firms exhibiting “not-invented-here”-attitudes.

<table>
<thead>
<tr>
<th></th>
<th>Organizational strategy, external search, and innovation performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Firms’ external search breadth affects innovation performance more strongly when an explorative innovation strategy is pursued than when an exploitative innovation strategy is pursued.</td>
</tr>
<tr>
<td>12</td>
<td>Firms’ external search depth affects innovation performance more strongly when an exploitative innovation strategy is pursued than when an explorative innovation strategy is pursued.</td>
</tr>
<tr>
<td>13</td>
<td>The relation between openness to external knowledge (i.e. search breadth and depth) and innovation performance is positively moderated by the pursuit of an ambidextrous innovation strategy (i.e. multiple innovation objectives).</td>
</tr>
<tr>
<td>14</td>
<td>Firms’ external search (i.e. breadth and depth) affects innovation performance stronger with an ambidextrous innovation strategy than with specialized ones.</td>
</tr>
</tbody>
</table>

Table 26: Overview results of hypotheses testing
6 Discussion of results, implications, and contributions

This research addresses the organizational alignment of firms with their open innovation activities. We contribute to theory by addressing a gap of insights in the literature regarding contingency and management conditions for firms’ success with open innovation. Building on existing research about the effects of organizational structure, organizational culture, and innovation strategy for external knowledge integration and innovation performance, we analyzed how these contingency factors affect firms’ open innovation performance. The results obtained provide answers to the research questions of this study (Chapter 2). Table 27 provides a comprehensive overview of these analyses. In the following, we will discuss the results and the theoretical implications and contributions of this research (Section 6.1). In Section 6.2, we provide managerial implications and conclude with a discussion of limitations and opportunities for further research.

6.1 Theoretical implications and contributions

6.1.1 External search breadth, external search depth, and innovation performance

Although evidence exists for the performance contributions of external knowledge (Cassiman and Veugelers, 2006; Katila and Ahuja, 2002; Laursen and Salter, 2006; Leiponen and Helfat, 2010; Rosenkopf and Nerkar, 2001; Rothaermel and Alexandre, 2009), the strategic differentiation of firms’ search behavior into search breadth and search depth and their respective performance effects has received only little attention (Chiang and Hung, 2010; Sofka and Grimpe, 2008).

Our examination of the effects of search breadth and depth with a newly generated sample in a different country and setting adds to the consolidation of the respective knowledge through a kind of “replication” study (Easley et al., 2000). In sum, we can confirm the positive effects that external knowledge sourcing has for the innovation output of companies. External search breadth and depth both exhibit positive effects on the innovation output of firms. Yet, at the same time, firms can reach a state where they “oversearch” and from which on a further utilization of outside knowledge sources leads to decreasing returns (Laursen and Salter, 2006). Extending the amount of collaboration partners too much is confirmed to lead to detrimental performance effects.
### Research Questions and Results

| RQ 1: Which effects do external search breadth and depth have on innovation performance? |
| RQ 2: Which effects do external search breadth and depth have for different degrees of innovativeness? |

Firms can enhance their innovation performance by engaging in broad and deep external knowledge search. Both these external search activities improve innovation performance, yet with increasing degrees of openness the performance impact shows declining marginal returns.

- Search breadth improves innovation performance for overall, incremental, and radical innovation performance.
- Search depth improves innovation performance for overall and incremental innovation performance.
- Deep search relations enhance incremental innovation steps whereas broad search enhances both incremental and radical innovation.

**RQ 3a: How does organizational structure as contingency factor matter for the openness-performance relation?**

The specialization of innovation-related tasks impacts on the relation between search breadth and overall, incremental, and radical innovation performance. However, the impact of specialization differs with regard to openness levels attained or pursued by firms.

- At low levels of openness, specialization levels may assume medium degrees
- At medium levels of openness, specialization at low levels is preferable
- At high openness levels, a higher degree of specialization is advantageous

The formalization of innovation-related tasks impacts positively on the relation between search breadth and overall and incremental innovation performance. However, also here openness levels attained matter.

- At low levels of openness, lower formalization levels show better performance impact
- With increasing openness, formalization becomes more beneficial
- At high levels of openness, high levels of formalization are preferable

**RQ 3b: How does organizational culture as contingency factor matter for the openness-performance relation?**

Firms can enhance their potential to benefit from open innovation through the alignment of their organizational culture. Especially the level of internal connectedness impacts on the relation between search breadth and (incremental) innovation performance. Additionally, also firms’ attitudes towards external knowledge matter for firms’ potential to reap the benefits from open innovation.

- At low levels of openness, performance impact is greater with low internal connectedness
- With increasing openness, internal connectedness becomes more important and more beneficial
- NIH impacts on the relation between search depth and overall, incremental, and radical innovation performance
- NIH impacts on the relation between search breadth and incremental innovation performance
- With higher openness levels, lower NIH becomes performance superior
Results and Implications

RQ 3c: How does innovation strategy as contingency factor matter for the openness-performance relation?

Through the formulation of innovation objectives, firms can enhance the performance impact of their external knowledge search activities. Especially, search depth profits from the alignment with strategic objectives and in particular from the alignment with ambidextrous innovation objectives. Search breadth, however, is found to not profit from the alignment with strategic objectives and only shows slight positive implications with exploitation objectives.

**Impact differences of exploration and exploitation**
- External search breadth does not profit more from exploration objectives than from exploitation objectives
- Rather, slight indication that breadth profits from exploitation orientation
- External search depth benefits more from exploitation than from exploration orientation

**Innovation strategy - impact of ambidextrous innovation strategies**
- Ambidexterity in innovation objectives impacts rather negatively on the relation between external search breadth and overall innovation performance
- Only at very low and very high levels of openness in terms of search breadth ambidexterity is beneficial
- Ambidexterity in innovation objectives impacts positively on the relation between external search depth and overall innovation performance
- The positive impact of ambidexterity in innovation objectives for external search depth increases with increasing openness levels

**Innovation strategy - impact differences of ambidextrous innovation strategies and specialized innovation strategies**

Firms with an ambidextrous innovation strategy show significant impact of search depth on innovation performance (but not for search breadth) and firms with specialized innovation strategies show significant impact of search breadth on innovation performance (but not for search depth).
- External search breadth does not affect innovation performance stronger with the pursuit of ambidextrous innovation strategies than with specialized innovation strategies
- External search depth affects innovation performance stronger with the pursuit of an ambidextrous innovation strategy than with specialized innovation strategies

| Table 27: Overview research questions and analysis results |
Further, our research shows that external search breadth has positive effects for both incremental and radical innovation performance. However, these positive effects are slightly lower for radical innovation performance than for incremental innovation performance. The “tipping point” from which on further external search turns negative is at a slightly later point for incremental innovations than in the case of radical innovations. This means that the decreasing returns to openness set in earlier for radical than for incremental innovation output. This indicates that search breadth is more conducive to the generation of incremental than radical innovation output.

Interestingly, external search depth only exerts its positive influence on incremental innovation performance, albeit the effects are lower than for search breadth. External search depth was not found to influence radical innovation performance. This is opposed to the findings of Laursen and Salter (2006), who find that external search breadth and depth are of importance for both incremental and radical innovation, but external search breadth decreases in effectiveness and external search depth increases in effectiveness with an increase of the degree of innovativeness. They argue that for generating radical innovation, that is, true deviations from the current state, only few external sources can actually provide the necessary information or knowledge. As radical innovation goes along with the creation and utilization of completely new knowledge, not too many potential partners exist, thus searching broadly is less effective. Rather, they argue, in an endeavor to generate radical innovation, firms should coalesce with a few chosen external partners who are in possession of the respective relevant knowledge.

The results of the present study tell a different story. Searching broadly enhances incremental and radical innovation performance, and as the effect size decreases from incremental to radical, search breadth may be constituted to be more effective for incremental innovation performance. But search depth only enhances incremental innovation performance and has no significant effects for radical innovation. Therefore, we can assert that broad search positively influences firms’ efforts to generate incremental and radical innovation, but deep external search only influences the generation of incremental innovation performance. Search depth does not increase in its effectiveness with increasing degrees of novelty. That is, search depth cannot be concluded to be more effective or appropriate for generating radical innovation.
performance than for the generation of incremental innovation performance.

In a recent study, Chiang and Hung (2010) found that external search depth only influences incremental innovation, whereas external search breadth influences only radical innovation. This is in line with previous research on organizational learning and external knowledge utilization. Broad and exploratory search has usually been associated with the ability to generate more radical innovation (He and Wong, 2004; Jansen et al., 2006). Bierly et al. (2009) finds that knowledge drawn from more distant sources is utilized more for the generation of radical innovation, whereas Atuahene-Gima (2005) clearly identify the different effects of exploration and exploitation on radical and incremental innovation, respectively. The notion of exploratory and exploitative learning has been brought forward by March (1991). He associated exploratory learning with access to and utilization of a wide array of external knowledge sources.

Also the literature on new product development has acknowledged the positive effects of searching for knowledge widely beyond the firm’s boundaries and usual search ranges. This exposes firms and employees to a broader diversity of ideas and knowledge, which may increase the chances of finding novel combinations and solutions and lead to the generation of truly novel solutions (Hargadon and Bechky, 2006; Hargadon and Sutton, 1997).

Additionally, when searching for innovation-related knowledge, firms often are victim of a “local search bias”. This describes the tendency of firms and people to search for knowledge and solutions often only within restricted search ranges and among sources they deem knowledgeable and with which they are familiar. That poses the threat of being focused on incremental improvements to the detriment of radical developments (Katila and Ahuja, 2002; Stuart and Podolny, 1996). In order to overcome the “local search”-tendency, firms are increasingly tapping into formal and informal linkages with different types of partners and are establishing inter-organizational networks in order to harness knowledge and innovative ideas from non-local domains that help them break path-dependent patterns of knowledge search accumulation (De Araújo, 2010; Laursen and Salter, 2006; Rosenkopf and Almeida, 2003).

Utilizing the argument of Laursen and Salter (2006), who argue that in the case of radical innovation only few sources which could provide the relevant missing
knowledge inputs may exist outside a firm’s boundaries, it can be argued that only through broad and wide search may a firm identify these few sources. Broad external search exposes a firm to more sources with different knowledge backgrounds (Rosenkopf and Nerkar, 2001). Broad external search, thus, is a means to overcome the negative effects of otherwise "local search” and to facilitate radical innovation performance. Deep external relations, on the other hand, require significant resource deployment, which may constrain firms in their possibilities to engage in deep relations with a comprehensive amount of external sources, thus curbing the potential to find sources with radical innovation information (Rowley et al., 2000:375).

6.1.2 External search, innovation performance, and the moderation effects of organizational structure

This study contributes to the understanding of the effects of external knowledge utilization by adopting a contingency perspective and investigating the effects the structural design of a firm has for the relation between external search and innovation performance. The structure of a firm's organization has significant implications for the potential to generate and utilize knowledge (Nonaka and Takeuchi, 1995; Pertusa-Ortega, 2010). Likewise, the search for external knowledge requires an appropriate organizational design (Cohen and Levinthal, 1990; Jansen et al., 2005). In this respect, three central organizational design variables were analyzed – specialization, formalization, and decentralization – which all represent variables that a firm’s management can actively influence.

The results indicate that the degree of specialization within an organization exerts mixed influence on a firm’s ability to profit from external search. Specialization was understood in this research as a differentiation of innovation activities regarding tasks or topics (e.g. existence of dedicated employees, teams, or functions for managing the search for external knowledge for instance). At lower levels of external search breadth, firms exhibiting higher degrees of specialization generate higher innovation returns as compared to those firms with lower degrees of specialization. Yet, this superiority decreases with increasing external search breadth and eventually turns around to the opposite. At intermediate levels of openness, low degrees of specialization seem to be more advantageous than high degrees of specialization, yet again, also this superiority
decreases with even further increasing search breadth. And eventually, firms with very high degrees of openness generate the highest innovation performance when adopting higher degrees of specialization again.

Looking at the effects of specialization from a different perspective, we could identify specialization to be rather harmful altogether and to be beneficial only at the fringes of the openness range, thus at very low or very high openness levels. At low openness levels, firms with medium levels of specialization profited most from increasing openness even further. Firms which were highly specialized were harmed by increasing their openness levels at this point. At medium openness levels, the firms with low specialization could gain the most from an increase in openness, whereas at very high openness levels, firms with high degrees of specialization could generate the highest marginal profits when increasing openness further. At this point, firms with low specialization were identified to generate negative marginal returns when increasing their openness further. These observations also hold for the second variable of organizational differentiation, which investigated the effects of structural separation, that is, the differentiation between units.

Research associates organizational specialization with positive effects – due to positive effects on organizations’ and individuals’ propensities to search outside and to innovate (Olson, et al., 2005; Rothaermel and Hess, 2007). Specialized organizations are also associated with a better capacity to utilize external knowledge and to implement in the later stages of innovation processes (Damanpour, 1991:580). Other research associates specialization with negative effects for firms’ innovation performance. Organizational specialization may limit the variety in the sources of external knowledge being drawn from, since specialists were found to engage in “narrow” search endeavours (Van den Bosch et al, 2003:95).

Our results equally provide evidence for these mixed effects. The existence of specialization facilitates external search and the utilization of external knowledge, but when the degree of external search activity becomes greater, specialization has, albeit the positive effects of specialized search may still be in place, negative effects for innovation performance altogether. As argued above, specialization has positive effects for the search of external knowledge, because functional or thematic specialists more readily search for and integrate external input into their knowledge generation efforts.
This is in line with Rothaermel and Hess (2007), who find that external knowledge utilization is facilitated by “star scientists”. These star scientists are well positioned to acquire external knowledge because of the specific thematic abilities they possess (Rothaermel and Hess, 2007:900). In addition, these individuals perform external search as their sole core job activity which increases their capacities to search and acquire external knowledge (Rothaermel and Hess, 2007:915).

Yet, knowledge acquisition is only half the path knowledge needs to take in order to have effects for innovation performance. It needs to be disseminated through the organization and applied at the right places (Fiol, 1996). Specialization, and thus the development of many smaller and sometimes isolated functional or thematic areas, hampers efficient knowledge exchange (Olson et al., 2005; Pertusa-Ortega et al., 2010). With increasing inter-unit boundaries, the costs of communication and learning rise, and internal knowledge transfer is hampered, which is detrimental for the performance effects of external knowledge (Colombo and Delmastro, 2008; Willem and Buelens, 2006).

Why, then, is specialization initially advantageous and later on (i.e. with higher external search breadth) becomes disadvantageous? A possible explanation may be that the positive effects of search specialization over-compensate the negative effects that specialization has for subsequent internal knowledge transfer. Due to specialization, knowledge search and acquisition is implemented more effectively and efficiently, and specialists are able to communicate the acquired knowledge well enough into the organization. Hence, they assume a similar role to Rothaermel and Hess’ (2007) “star scientists” or “gate-keepers”, who manage the interface between a firm and its external environment (Tushman, 1977). The organization suffers from the specialization of a search function with regard to internal knowledge transfer, but still manages to disseminate and integrate the knowledge. This is because at the lower end of external search breadth, the number of external sources is still small, which may also mean that smaller amounts of knowledge have to be acquired, understood, and transferred, thus placing a smaller burden on the internal transfer mechanisms. The variance of inputs may be lower, too, compared to when more external sources are utilized. Lower variance places a smaller burden on the “sensemaking” capacities of search specialists and the organization as a whole (Weick, 1995). Whereas with an increase in external
search breadth the amount and variance of knowledge to be absorbed increase and the positive effects that search specialization has are outweighed by the now more cumbersome knowledge transfer. The organization cannot sufficiently process the knowledge anymore and integration supersedes specialization due to the positive effects that integration has for internal knowledge transfer (Hansen, 1999).

The analysis of the moderation effects of specialization shows that at very high levels of search breadth, higher specialization again outst outst lower specialization. Facing a great number of external sources, the “burden” of knowledge search and integration may again flip more strongly to the search side. Now again, specialization in external search increases a firm’s ability to profit from external search more than it places a burden on knowledge transfer internally. The related thematic knowledge that specialists and specialized units possess (Lane and Lubatkin, 1998) as well as the expertise that these individuals and units possess in conducting search processes may outweigh the “costs” of internal knowledge transfer.

Our results indicate that specialization is beneficial when external search is low but becomes disadvantageous when external search is high. We have argued that this is because of the different effects that specialization has for the different respective activities associated with external knowledge utilization. Further research may build on our results for specialization and investigate more in detail how organizations can manage the trade-off between the different organizational arrangements required for search and integration.

As to the second dimension of organizational design – formalization – this research shows that at low openness levels, firms do better with low formalization. With higher openness, or external search breadth, firms with higher degrees of formalization benefit more in terms of innovation performance, whereas firms with lower degrees of formalization even see decreasing innovation performance with increasing external search breadth. Hence, formalization has positive implications for external knowledge search and increasingly so with increasing openness. Additionally, formalization shows significant positive interaction for the generation of radical innovation performance. Especially the generation of radical innovation output may require formalization, as it usually entails searching among unknown sources and acquiring truly new knowledge.

The analysis of the marginal effects of openness confirms these findings. An increase of
openness benefits those firms more which apply medium to high levels of formalization. The results show that at lower levels of external search breadth, lower formalization is superior to high formalization and that this relation turns around with higher search breadth. Yet, firms increasing their openness levels generate the highest extra benefits when assuming a medium to high degree of formalization throughout the whole range of openness levels.

Previous research associates formalization with negative effects, as it restricts the search scope of firms (Jansen et al., 2005; Weick, 1979). But, again, formalization has also been found to have positive implications, as it facilitates knowledge identification and evaluation (Jansen et al., 2005; Vega-Jurado et al., 2008b). Through the definition of procedures the ambiguity surrounding the application of new knowledge can be reduced (Pertusa-Ortega et al., 2010). According to the findings in the literature about the effects of formalization, knowledge search is hampered by formalization, whereas knowledge integration is facilitated by formalization (Weick, 1979; Kohli and Jaworski, 1990; Lin and Germain, 2003; Jansen et al., 2005). Our results add insights to the discussion about the effects of formalization for external knowledge utilization. We contribute to theory by uncovering that the degree of openness, thus the amount of sources and knowledge sought and acquired, matters for the evaluation of the effects of organizational formalization and the actual degree thereof.

In line with the previous argument concerning the effects of specialization, when the search extent is small, the “bottleneck” does not lay so much with internal knowledge transfer, thus implementing structures facilitating the actual search are superior. With an increase in knowledge sources, this changes and the focus of an organization should be on internal transfer rather than search, hence on implementing structural arrangements facilitating knowledge transfer. Also Jansen et al. (2005) find that formalization is positively related to firms’ realized absorptive capacity, that is, the eventual application of externally acquired knowledge. However, they also cannot find support for the hypothesis that the actual acquisition, or search in our terms, is negatively influenced by formalization (Jansen et al., 2005). This is in line with our finding, which indicates lower degrees of formalization to be beneficial for lower degrees of openness and higher degrees of formalization for greater openness levels.

Further research may explicate in more detail the actual effects of formalization, or,
explicate what formalization actually means. We have employed a rather broad measure to capture formalization. Further research may (a) employ more fine-grained quantitative measures for formalization or (b) disentangle the effects of formalization through the means of case studies. This may help to understand the effects of formalization better, which aspects should be formalized and when as well as in which manner this should happen, thus how formalization should best be implemented. Future research may draw from other literature which associates formalization with positive effects and conceptions, such as “semi-structures” (Brown and Eisenhardt, 1997) or also an “enabling bureaucracy” (Adler and Borys, 1996). All these regard formalization as a beneficial element of organizations, yet acknowledge the importance of integrating elements counteracting the possible negative effects. Such an element may be found in the degree of connectedness and integration that firms exhibit. Hence, further research should also engage in detailing possible interaction effects between elements of organizational structure and culture.

Regarding the third variable of investigation – decentralization – we find it to be insignificant for supporting open innovation performance. Yet, the signs of interaction are in line with the assumed positive moderation effect of decentralization. Previous research has found centralization to have a negative impact on knowledge performance (Pertusa-Ortega et al., 2010) or knowledge creation (Ouchi, 2006) and decentralization to be positive for knowledge absorption and integration (Jansen et al., 2005). The results of this study, however, do not support these findings by means of statistically significant results. For the decision to allow for lower level participation in decision making, this research cannot make any clear assertion. However, also other research fails to constitute significant results for decentralization (Frost et al., 2002; Wijk et al., 2008).

Reasons for this may be found in various aspects. For one, the insignificance may be explained by possible interaction effects of decentralization and third variables. For example, Lin and Germain (2003) find an interaction of formalization and decentralization with regard to the utilization of customer knowledge and concluded for their sample of Chinese firms that decentralization follows formalization in the attempt to restructure organizations. Secondly, decentralization may be implied in and conceptually similar to the specialization variable employed in this research. Lin and Germain (2003:1149), for instance, emphasize that decentralization can be attained
through divisionalization. Further research may also embrace these results and examine why there are no significant effects for decentralization.

6.1.3 External search, innovation performance, and the moderation effects of organizational culture

In a second contingency framed investigation we set out to examine the moderating effect of different aspects of an organization’s culture on the openness-innovation-performance relation. Organizational culture is frequently highlighted as important for the implementation of open innovation (Gassmann et al., 2010; Huizingh, 2011; Lichtenthaler, 2011; Van de Vrande et al., 2010). Special emphasis is often given to aspects such as communication and attitudes towards external knowledge (Chesbrough and Crowther, 2006; Keupp and Gassmann, 2009; Luoma et al., 2010). However, also here, the empirical evidence is scarce (Mortara et al., 2010; Van der Meer, 2007).

Organizational culture represents an intangible attribute of a firm. Therefore, we built on the concept of market orientation as a cultural trait of organizations (Baker and Sinkula, 1999; Jaworski and Kohli, 1993) and examined the effects of open mindedness, internal connectedness, and attitudes towards external knowledge, instead.

In Hypothesis 8 we stated that firms would profit from being internally connected. Our results provide slight evidence for this assumption, which is in line with previous research. Especially with increasing openness and at high levels of openness, internal connectedness is found to be an important facilitator of the success of firms’ broad search activities. An important aspect of firms’ success with the utilization of external knowledge is the internal application of that very knowledge (Lichtenthaler and Lichtenthaler, 2009). Fundamental to this is the exchange of ideas and knowledge inside the firm (Inkpen, 1996). According to Jansen et al. (2005), the degree of internal connectedness is of utmost importance for internal knowledge transfer and application. High connectedness inside firms means that employees and units have the chance to be more acquainted with each other, to develop trust towards each other, and to generate a common language and modus operandi among themselves (Rowley et al., 2000). This in turn means that high connectedness inside a firm alleviates units and employees getting in touch with each other, thereby facilitating the exchange of knowledge (Galunic and Rodan, 1998; Jaworski and Kohli, 1993; Rowley et al., 2000).
Internal connectedness is of particular importance when openness is high, but at lower levels, low connectedness is shown to be better. Thus, we add to theory by showing that connectedness matters and is largely beneficial. But future research may engage in detailing the effects of internal connectedness further. Connectedness may also have negative implications, such as for instance, the emergence of “group think” (Janis, 1971). Another approach may be the examination of the different aspects of open innovation utilization - search, and integration. Internal connectedness may have different effects on both (Jansen et al., 2005). As such, connectedness may be rather harmful for search but positive for transfer and integration. If so, the degree of openness and the amount of knowledge may again be the possible explanation for the differences. Low openness, hence low amounts of knowledge, lead to the focus being on the actual search, and assuming that connectedness has negative implications here, low connectedness should be the choice. With increasing openness, the amount of knowledge increases and the focus may shift to internally processing this knowledge. Now, internal connectedness may be of advantage, as it facilitates communication and exchange within the firm (Jansen et al., 2005). A question arising from that, which is of particular importance for management practice, concerns the actual creation or implementation of internal connectedness. How can firms create such connectedness, which measures have to be taken and are most appropriate? Future research may embrace our results and analyze the implications and implementation or generation of firm internal connectedness for external knowledge search activities more in detail.

As a further result, we find no support for Hypothesis 9, in which we stated that a firm’s open mindedness would also have a positive influence for the performance effects of external search. We suggested that for knowledge to be freely exchanged within the organization, a general attitude of openness towards new ideas and the reflection of established views was a critical prerequisite (Baker and Sinkula, 1999; Porac and Thomas, 1990). There may be an explanation within the degree of connectedness, as high connectedness may require a certain openness to new and other ideas and knowledge and the ability to question one's own views. However, this result necessitates further research.

As of the third aspect of organizational culture, the attitudes towards external knowledge being termed “not-invented-here”-syndrome (NIH) were expected to bear
negative implications for firms’ potential to benefit from external knowledge search. If firms show strong tendencies to reject ideas and knowledge originating outside the own organization only for that very reason, they are deemed to suffer from the NIH-syndrome (Katz and Allen, 1982; Herzog, 2008). This is of particular severity if firms try to systematically utilize external ideas and knowledge for improving their innovation performance (Lichtenthaler and Ernst, 2006).

The results show that NIH is especially problematic for deep search relations (i.e. external search depth), higher degrees of openness, and the generation of radical innovation performance. The generation of radical innovations necessitates the utilization of truly new knowledge and ideas (Dewar and Dutton, 1986:1423). This usually brings about that firms have to engage with new partners to tap into their knowledge pool and acquire access to novel information (Abernathy and Utterback, 1978). A strong “not-invented-here”-attitude is obviously detrimental to successful adoption of knowledge in this case. Further, the results indicate that deep external search relations suffer from the existence of NIH, whereas search breadth shows no significant implications of NIH. Deep search relations represent relations, usually characterized by high intensity of the relation, determination to achieve specific objectives and trust between the partners (Chiang and Hung, 2010:294; Laursen and Salter, 2006:136; Rowley et al., 2000:369). For an intense and trusting relation between partners, which is intended to achieve specific longer-term objectives, NIH may be of particular harm. Broad external search on the other hand usually intends to screen the environment rather shallowly for new knowledge inputs (Chiang and Hung, 2010:294; Laursen and Salter, 2006:136). For this kind of search relation, NIH again may be less of a problem.

When openness levels are low (i.e. low search depth), however, our results indicate that NIH is less problematic than one might have expected. At low openness levels, the amount of external partners or sources and knowledge sought for and acquired is usually still small. The efforts to engage in exchange, communication, and evaluation are lower. Thus, firms may have more resources available and more time to engage in relation-specific exchange and communication. As there is more time to reflect upon single knowledge inputs, initial NIH-tendencies may eventually be overcome. As another consequence, firms may get acquainted more easily with these partners, and
their respective knowledge inputs may be evaluated more easily and more swiftly as compared with situations where firms are exposed to a larger amount of external sources and therefore also knowledge inputs. Also, with fewer (and especially deep) relation partners, individual relations may be easier to manage and a common modus vivendi easier to establish (Laursen and Salter, 2006:136). Altogether, this may help to compensate NIH-related caveats, and these might not influence the eventual evaluation as directly and definitely, therefore bearing lesser impact on the eventual implication of the acquired knowledge for innovation performance.

Our results suggest that NIH might be less critical, especially at low openness stages. Perhaps, it may even have positive implications. For reasoning this, we invoke an argument put forward by Lichtenthaler and Ernst (2006). They discussed the possibility that firms suffer from the opposite of NIH, which would be a too optimistic and affirmative view on the opportunities associated with open innovation or external knowledge and ideas in general. This was called “buy-in”-syndrome (Lichtenthaler and Ernst, 2006:372). Interpreted differently, NIH may not have to be seen as critically as is usually the case. A slightly skeptical, or critical, reflective, or careful approach towards external knowledge may be appropriate in order to prevent falling for the belief that external knowledge is a remedy to all internal innovation generation problems. NIH may, accordingly, be interpreted not as a rejection of everything from outside the firm but as an indication of business acumen.

Either way, our results show that the investigation of the “not-invented-here”-syndrome and, more generally, of organizational beliefs, and their influences on firms’ potential to benefit from external knowledge is necessary. Further research, detailing the NIH-syndrome and its potential effects more specifically, is highly advisable. Future research may reexamine the effects of the “not-invented-here”-syndrome, developing a more fine-grained picture of its effects. Future research should engage in efforts to develop more comprehensive measures, taking into account individual and behavioral aspects of the development and impact of certain attitudes. This should encompass the effects of attitudes which are overly positive towards external knowledge. As we find only little evidence for search breadth being affected by NIH, future research may generate further insights, as “not-invented-here” may only or particularly be relevant for certain search relations. The intentions behind any one search strategy may be of importance here.
Search breadth may often be used for simply screening the environment for possible knowledge inputs. Hence, it is rather shallow and not bound to particular objectives. The “not-invented-here”-syndrome may be only or particularly of detrimental effect when relations are focused on the generation of defined aims.

6.1.4 Structural and cultural contingencies and organic versus mechanistic organizations

Overall, our research suggests that contingency aspects matter and adds to the theoretical knowledge about firms’ ability to benefit from external knowledge search. In particular, the investigation of structure and culture provide important insights for the advancement of theoretical knowledge. Referring to the distinction made between mechanistic and organic structures (Burns and Stalker, 1961), we find elements of both being important facilitators of open innovation success. Organizations which can be termed as “organic” can be characterized by low formalization, low specialization as well as high decentralization, whereas “mechanistic” organizations exhibit rather high formalization, specialization, and centralization (Burns and Stalker, 1961). Literature associates different elements characteristic of organic designs with higher potential to innovate (Aiken and Hage, 1971; Burns and Stalker, 1961; Damanpour, 1991; Lam, 2004; Mintzberg, 1979; Pierce and Delbecq, 1977; Volberda, 1998). Furthermore, deploying rather organic ways of structuring and working is associated with a greater ability to engage with external parties, thus to utilize open innovation (Dittrich and Duysters, 2007).

Yet, rather than identifying only organic or mechanistic elements, our analysis finds a blend of elements to be conducive to open innovation. We can conclude that a more structured and formalized approach is most suitable for open innovation. But our analysis also reveals that other elements favorable for open innovation tend to stem from the organic corner, e.g. low specialization and high internal connectedness. This indicates that there may be interrelations between organic and mechanistic elements. Certain elements may compensate their respective effects or complement each other. Sheremata (2000:389) confirms this, as she finds that elements for successful product development can be a complex mix of structural elements, some of which appear to be organic while others are more mechanistic. Future research may take this as a starting
point for further investigations of blends of organic and mechanistic elements and the identification of suitable organizational settings most supportive for open innovation.

6.1.5 External search, innovation performance, and the moderation effects of innovation strategy

Exploration and exploitation can be conceptualized as foci of a firm’s innovation strategy (He and Wong, 2004). The alignment of firms’ external search efforts with their innovation orientation is crucial for innovation success (Lichtenthaler and Ernst, 2009). Capturing the dominant focus of firms’ innovation strategy by the two dimensions of “exploration” and “exploitation”, hence the generation of truly new products or the further development of existing products, this study contributes to theory by examining the interplay between firms’ exploitative and explorative innovation strategies and firms’ external search activities (Harryson et al., 2008). Both are important levers for management, and topics widely discussed in research. In particular, this research contributes to theory by investigating how firms’ exploration and exploitation orientation can be aligned to firms’ external knowledge search.

Building on the distinction of external search breadth and depth, we asked (a) which innovation orientation suits which external search mode better, and (b) whether the pursuit of multiple and diverse goals is beneficial for firms’ efforts to increase innovation performance by means of either external search breadth or depth.

Different search modes may require or be more appropriate for different strategic orientations. Yet both the literature on exploration and exploitation activities of firms as well as the literature concerning firms’ external knowledge search efforts have largely left the question of their respective alignment unconsidered (Lane et al., 2006; Raisch et al., 2009). Research suggests that both exploration and exploitation are necessary for firms’ innovation performance (March, 1991) as well as that searching for knowledge outside firms’ boundaries is crucial for performance (Laursen and Salter, 2006). Adding to this, Rosenkopf and Nerkar (2001:289) and also Rothaermel and Alexandre (2009:761-762) argue that both exploration and exploitation can be directed outside of the firm’s boundaries as well as inside.

According to the literature in the realm of network theory, search breadth can be compared to weak ties and their effects (Bergenholtz, 2011). Weak ties are asserted to be well suited for rather shallow and exploratory search, whereas strong ties –
resembling deep search – rather suits focused and exploitative search (Dittrich and Duysters, 2007; Nooteboom and Gilsing, 2004).

Our analysis suggests that broad as well as deep search relations rather benefit from exploitative than from explorative search objectives. We find no evidence that firms pursuing exploration objectives profit more from breadth in external search than firms with an exploitation mode. Rather, the evidence suggests that exploration reduces the impact of search breadth on innovation performance and that explorers rather benefit from search depth. Yet, we find evidence that firms with an exploitation mode profit more from depth than explorers do. Put differently, deep relations are more beneficial when aligned with either exploration or exploitation innovation orientation. Yet, deep relations benefit more from exploitation than from exploration. Broad search relations, however, do not gain from being aligned with exploration but rather also from the alignment with exploitation.

The results we obtained present a contradiction to the theoretical and empirical evidence concerning the application and effects of search breadth and depth, or weak and strong ties. Broad search aims at the utilization of many different external sources and was suggested to benefit exploratory search endeavors (Rowley et al., 2000). Our results do not support this suggestion. Broad search may be too shallow and unfocused to be utilized for search efforts directed at specific goals, either exploratory or exploitative ones. However, our results suggest that deep search relations benefit both exploratory and exploitative search objectives. Deep search relations constitute linkages to external sources which are characterized by intensity and stability (Laursen and Salter, 2006; Sofka and Grimpe, 2008). In this, they resemble strong ties and may provide the more suitable “channel” for the pursuit of specific innovation objectives. Especially exploration endeavors may require that relations are more long-term, since the development and acquisition of exploration relevant knowledge is less straight-forward as in the case of exploitation-related knowledge, due to exploration-related knowledge often being tacit in nature (Lane and Lubatkin, 2006:462-463; Lavie and Rosenkopf, 2006:799; Rothaermel, 2001:690). Stable and intense relations may be the prerequisite for the generation of truly novel knowledge and information, which oftentimes is tacit in nature (Bierly et al., 2009:490). Thus, deep external linkages are conducive to exploration efforts. Yet, deep external linkages are also shown to benefit from exploitation objectives. These aim at the refinement of existing knowledge and
products, which in turn may require more long-term relationships with certain key partners (Chiang and Hung, 2010:294). Hence, again, deep linkages are more conducive to broad ones. Regardless of the actual direction and content, the definition, communication, and implementation of specific objectives, may only be possible through external relations which offer certain intensity, occurrence frequency and thus quality.

The analysis of the alignment of ambidextrous innovation strategies also reveals search depth to be the more appropriate search strategy. Broad search initially benefits from ambidexterity in innovation objectives, but at higher openness levels ambidexterity becomes detrimental to innovation performance. Deep linkages, however, profit from ambidexterity. A further analysis reveals that broad search is rather suitable for the pursuit of specialized strategies and deep search for the pursuit of ambidextrous strategies. Ambidexterity in innovation objectives, hence the simultaneous pursuit of exploitation and exploration objectives, certainly requires more attention and absorption resources and capacities than the pursuit of single objectives. Broad search relations may simply be too weak to handle this multitude of requirements and only deep external relations offer the strength and stability to engage in the pursuit of several (even conflicting) objectives.

Overall, the results are partly deviating from existing research and offer opportunities for further research detailing the effects of exploration and exploitation for external search breadth and depth. Usually, broad linkages are associated with the exploration intentions and activities of firms (Dittrich and Duysters, 2007:513; Rowley et al., 2000:384) and broad search is asserted to be a means for the generation of radical innovation, while deep search is usually associated with incremental innovation and exploitation (Chiang and Hung, 2010:294; Rowley et al., 2000:384). Future research may need to detail the analysis as to why search breadth does not positively interact with exploration, and re-examine our evidence that search depth is also conducive to exploration. It may well be that breadth rather suits radical and depth rather incremental innovation objectives. However, there are arguments as to why deep search is supportive for the generation of radical innovation, too. The push in that direction by

31 Knowledge inputs for exploration often deviate from firms’ existing knowledge and are tacit in nature. Only intense and stable relations may therefore provide the adequate generation and transfer “channel” (see Section 3.4).
means of strategic direction (e.g. through the formulation of an exploration strategy) may then simply facilitate and strengthen the general adequacy of search depth for exploration. Search breadth may rather lead to radical innovation because of its inherent search in wider and more diverse fields and thus the inherent potential to discover unusual partners and knowledge or ideas. Yet, this may be more a result of serendipity and the capacity of a firm to adequately understand and apply respective knowledge inputs. Focusing and directing broad search towards the generation of exploration and thus radical innovation, however, builds up success pressure, brings in business objectives and reasoning, and thus constrains the effects of broad search, eventually leading to lesser impact. Search depth, on the other hand, as a long-term and intense search effort with regard to the relation with an external source but also with regard to the respective engagement of the own firm, offers a “broader” and more resilient search conduit.

Further, our research utilized the broad concepts of search breadth and depth, yet there is reason to assume that different source types have different potential or effects for innovation performance, and thus may be more or less suitable for the alignment with exploration or exploitation objectives (Köhler et al., 2009). Future research may take this into account.

Our research also allows qualifying the performance effects of external search and ambidexterity. Research has shown that searching for knowledge among a multitude of sources and pursuing ambidextrous (or multiple) goals is beneficial for performance (Leiponen and Helfat, 2010; Rothaermel and Alexandre, 2009). We add to theory by investigating these effects with a more detailed perspective on external search. In our analysis, broad search was shown to be rather inappropriate for ambidextrous innovation objectives, whereas deep search provides the necessary stability and intensity. In line with the above reasoning, only deep search linkages may provide the quality, strength, and engagement level on the side of the searching firm that is necessary for the ability of firms to draw knowledge for the pursuit of multiple and diverse objectives.
6.2 Implications for management practice

Beyond the theoretical contributions, our results also bear important insights for managerial practice in innovation management and in particular for the management of open innovation activities. Our results suggest approaches to align internal dimensions of organizational structure, culture, and strategy with firms’ attempts to increase their innovation performance by means of external knowledge search and the discretionary dimensions search breadth and search depth. The next section details the implications for managerial practice which are summarized in Figure 35 to Figure 39.

External search breadth, external search depth, and innovation performance

Our research confirms the positive innovation performance effects management can generate through extending their knowledge generation efforts to firm-external parties. Firms can engage in broad or deep external search relations. Our research shows that both dimensions provide firms with very distinct means to search for knowledge. External search breadth and depth exhibit limited and differential implications for innovation performance. In order to fully utilize the respective potential external search needs to be managed consciously, hence search activities need to be directed and calibrated with regard to their utilization extent and their appropriateness for different innovation outputs.

Both search activities entail effort and costs. These stem from the actual search for external knowledge sources and the interaction with them, as well as from the subsequent efforts to integrate and utilize the acquired knowledge. Management has to be aware that the more external sources it chooses to utilize the better innovation performance will be initially. But as firms’ capacities are limited, the associated costs will rise and eventually exceed the benefits of external search. Hence, from a certain utilization level onwards more openness creates more extra costs than extra benefit. As a result, the innovation performance impact turns negative and overall innovation performance decreases. Thus, our study confirms the importance for managers to be aware that open innovation or the utilization of external knowledge is not exclusively beneficial. Firms searching for knowledge outside their own boundaries need to tread consciously and find the point of balance between beneficial and harmful openness.

Further, our research informs management about the opportunities to affect certain innovation outputs by engaging in broad or deep external search. Both search
dimensions are associated with different innovation outcomes (Chiang and Hung, 2010; Laursen and Salter, 2006). Our results provide evidence that both broad search and deep search relations imply positive effects for the generation of incremental innovation outcomes. For radical innovation performance, however, only broad search is of benefit. In general, the generation of innovation requires new knowledge or new recombinations of knowledge (Eisenhardt and Martin, 2000), but this is especially true for radical innovation (Schoenmakers and Duysters, 2010). If firms want to generate truly novel ideas or knowledge they need to, first and foremost, stray from known knowledge and sources. Instead, firms need to engage with knowledge sources the previously did not engage with. As it may be rather difficult to know before which sources that may eventually be, utilizing an array of sources as wide as possible is advisable. Broad external search provides firms with exactly the means to search widely for diverse and new knowledge inputs.

**Figure 35: Managerial recommendations - search strategies**

Against the background of these assertions, management may rightly attempt to influence their individual openness-performance impact relation and ask which means may be most suitable to tailor their organizations for higher openness impact. Thus, in a second step, this research investigated means that managers and firms may employ to influence their firms’ potential to benefit from open innovation.

We find that managers have substantial leeway in embedding their organizations’ external knowledge utilization efforts. Firms can align their structures and culture to benefit more from open innovation and they can align their search activities with suitable strategic directions. In detail, our study provides managers with insights about the effects of organizational specialization and formalization as components of an organization’s structure as well as internal connectedness and “not-invented-here”-attitudes as components of an organization’s culture, and firms’ innovation orientation.
in terms of their intentions regarding exploration and exploitation activities.

**External search, innovation performance and the moderation effects of organizational structure and culture**

**Specialization** refers to the separation of innovation-related activities within firms. This can be single departments or units solely responsible for particular topics or tasks. If firms operate at very low or very high levels of openness, our research suggests management should implement specialized structural arrangements. In intermediate openness levels, however, we find that managers are better advised to refrain from separating functional units and responsibilities. That means management has to assess where on the openness slope the firm is positioned before deciding on its structural design. In addition, our study shows that firms relying on specialization do benefit less from increases of openness levels, which means increasing their search breadth. As our results show, low specialists profit more from increasing openness at low and intermediate initial openness levels. That means, if firms are at intermediate levels of external knowledge search and their management intends to extent their utilization of external knowledge sources, firms benefit more from this increase when they reduce organizational specialization. Only when firms are already at very high levels of openness, management may consider implementing specialized search functions as our results show that firms utilizing large amounts of external sources perform better with specialized organizational structures. In order to increase their firms’ potential to benefit from external search, managers are advised to reduce organizational specialization and rather rely on integrated approaches. The detachment within the organization rather harms firms’ potential to gain from openness.

In sum, that means that firms operating at lower openness levels can well utilize the benefits of specialization. But should these firms consider increasing their openness levels, their structural arrangement would be detrimental to increasing innovation performance and they would need to restructure. Hence, even at the beginning, at low levels of openness, firms should only adopt medium levels of specialization and not over-specialize, too.

**Formalization** refers to the definition and formulation of procedures and processes regarding the conduct of innovation-related tasks. The results of this study reveal that formalization facilitates the utilization of open innovation (i.e. external search breadth
in this case). Thus, in order to ensure that their firms benefit from searching knowledge externally, managers should define clear processes and guidelines as well as responsibilities for steering their firms’ external search and integration activities. Processes and guidelines provide guidance for the aim and initiation of external search, for the choice of issues or questions for which answers shall be searched for outside firm boundaries, for the choice of external sources or partners, for the initiation and implementation of the interaction as well as regarding criteria for evaluation and mechanisms for the transfer of new knowledge inside the organization. As the amount of external sources and knowledge acquired can quickly attain large dimensions, search and integration activities can easily become opaque, difficult, and cumbersome. Employees may be uncertain as to if they can just engage in external search with any of their questions and problems. They may be uncertain with regard to which external partners are appropriate and with whom management appreciates interaction. Further, they may not know what to do with knowledge they acquired, how to transfer it into the organization’s existing processes or project management structures. This is particularly so, if firms aim at raising their radical innovation performance and thus engage with unknown sources and tread in unknown fields. Defining clear rules, mechanisms, and responsibilities for conducting the search and transfer may alleviate the information overload of hitherto unspecified knowledge search and transfer procedures. Thus, our results suggest and advise managers to assist their organizations and employees by relying on formalization to raise the benefits of open innovation.

**Management implications structural alignment**

- Reduce differentiation of (innovation) functions, rather integrated approach (low specialization)
- Utilize specialization only for very high or low levels of openness; benefits outweigh downsides
- Define processes and procedures for external knowledge search and integration (high formalization)

*Figure 36: Managerial recommendations - organizational structure*

**Internal connectedness** reflects the extent to which departments, units, and employees are socially integrated with each other within a firm (Jansen et al., 2005). Higher degrees of connectedness imply that it is easier and more common to reach out to respective others, to communicate and exchange thoughts, ideas, and knowledge freely.
This increases the efficiency of the intra-organizational knowledge transfer, which is a fundamental prerequisite for successful application of knowledge acquired through the means of open innovation (Galunic and Rodan, 1998; Lichtenthaler, 2011). Albeit not quite so important at lower levels of openness, it becomes a very crucial factor when firms increase their search breadth. According to our results, managers who intend to improve their firms’ ability to profit from open innovation should implement measures to increase their firms’ degree of internal connectedness. They need to pay attention to the ability of their organizations, or rather employees, to reach out to their colleagues easily and without cumbersome processes in order to communicate and exchange knowledge.

The attitudes of an organization and its employees were found to be another crucial aspect for open innovation performance that managers need to be aware of. In this regard, management needs to assess the existence of negative attitudes towards external knowledge and whether their organization suffers from the “not-invented-here”-attitude (NIH). This concerns attitudes or beliefs which are commonly shared within the organization and which rather disregard external knowledge inputs for the sole reason that they are from outside the firm (Herzog, 2008; Katz and Allen, 1982; Lichtenthaler and Ernst, 2006). Firms may adopt a too adverse approach towards knowledge coming into the organization from outside. This, in turn, may adversely influence the motivation to search and engage with external sources as well as the evaluation of external knowledge in a manner that the adoption of outside knowledge or ideas would be rejected solely on the ground of the fact that they are external. Eventually, this may lead to the false rejection of good knowledge. Our research largely confirms that the “not-invented-here”-syndrome has negative implications for firms’ innovation success. Especially, when attempting to improve the radical innovation performance of firms, when engaging in deep external linkages, and when operating with great openness degrees, NIH has clearly negative effects. Managers need to identify, whether and to which extent their firm is affected by NIH, and implement remedies to reduce such overly negative attitudes.
External search, innovation performance and the effects of innovation strategy

Further we investigated how the definition of a firm’s innovation objectives or strategy aligns with its external search efforts. Our research shows that firms’ knowledge search can also be facilitated by setting appropriate innovation objectives. A common conceptualization of innovation objectives differentiates exploitation as firms’ efforts to improve existing products for existing customers and markets, and exploration as the efforts of firms to develop new products for new customers and markets.

Our study found that search breadth is neither positively related to exploitation nor to exploration. Broad search relations aim at the screening and utilization of a large and diverse amount of knowledge sources. Therefore, they may just be too weak and shallow for the pursuit of clearly defined goals. Thus, search breadth may be simply a general means to scan the environment broadly without the clear objective of finding knowledge for exploration or exploitation purposes, respectively. Depth in external search relations, however, was found to be appropriate for the alignment with both strategic objectives. Although, exploitation goals lead to a superior performance impact than exploration goals, both enhance the performance impact of search depth. Thus, managers intending to pursue a clear set of goals with their firms’ external search have to choose the appropriate knowledge search strategy. Search depth was found to offer the better choice in this respect.

The same applies to the simultaneous pursuit of both innovation orientations (i.e. ambidextrous innovation strategy). Our research recommends to only aligning search depth with such strategic orientation. Only for search depth, ambidexterity in innovation objectives is performance enhancing, while search breadth suffers from the pursuit of too many goals. Only search depth offers the conditions to engage in versatile innovation endeavors and thus to pursue multiple and different innovation objectives.
Firms attempting to pursue multiple innovation objectives by means of open innovation should opt for the engagement in a sufficient amount of deep external search relations.

**Management implications - strategy alignment**

- Only align search depth with strategic objectives
- Leave search breadth better unaligned with specific objectives
- Search breadth rather general, broad and undirected scanning of the environment
- Alignment of deep search activities with both exploration or exploitation objectives increases innovation performance
- The pursuit of ambidextrous innovation strategies is best aligned with search depth (depth has the necessary relation strength)

**Figure 38: Managerial recommendations - innovation strategy**

Finally, our study provides three more general conclusions for managerial practice with regard to external search efforts and organizational alignment. Our study reveals that the appropriate definition of the structural, cultural, and strategic context depends on the level of openness. Conditions suitable for lower openness levels turn out to be less beneficial for higher openness levels, and vice versa. Before managers determine the specifications of their firms’ organizational setting they need to assess the current openness levels as well as the further development – does the firm intend to further increase openness levels or not.

The impact differences with regard to the different openness levels may be explained by the different implications of organizational conditions for actual search and for the subsequent knowledge integration, thus the internal knowledge transfer. What is beneficial for the actual search may not be beneficial for internal knowledge transfer, and vice versa. When openness levels are low, also the amount of knowledge is low and the focus may be put more on the search itself. With increasing openness and knowledge inputs, this may turn around, and the internal transfer comes to the fore. Hence, conditions once beneficial – because they facilitated search – become inferior because they inhibit internal knowledge transfer.

A last general insight that this study revealed concerns the nature of structural and cultural variables. We built on the distinction between mechanistic and organic organizational settings. These represent very basic and generic characterizations of organizations, yet still emphasize the major aspects of how organizations function
Mechanistic organizations are usually associated with lower and rather incremental innovativeness as well as stable environments, whereas organic organizations are suited better to the opposite, dynamic environments in which change and innovation is required (Burns and Stalker, 1961; Jansen, 2005:27). The variables we find to be of importance, though, stem from both realms – low specialization and high connectedness are rather organic elements and high formalization rather mechanistic. Thus managers should be wary of simple recommendations that argue that either utmost flexibility or rigid order is the option to choose. Rather, it shows that an organization containing elements of both is most appropriate.

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<thead>
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<th>Management implications general organizational alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Differentiate and calibrate facilitator specification according to openness level and future direction (maintenance vs. increase of openness level)</td>
</tr>
<tr>
<td>- Distinguish between facilitating knowledge search and knowledge integration in facilitator specification (identify organization's aims and bottlenecks)</td>
</tr>
<tr>
<td>- Combine organic and mechanistic elements for aligning organization</td>
</tr>
</tbody>
</table>

Figure 39: Managerial recommendations - general

6.3 Research limitations and further research opportunities

Despite the thorough preparation and conduct of this research, as discussed in Chapter 4, the present study has several limitations as well as opportunities for further research, which will now be discussed. First, the data were collected through self-reported assessments of managers. We employed several means to alleviate concerns regarding single-informant-bias, still issues of key informant bias and common method bias may have to be borne in mind when interpreting the results. Secondly, the data we employed for our analysis are cross-sectional in nature, which usually improves validity of results. Given the differences in industries’ production processes and utilization of external knowledge, concerns may arise regarding the establishment of causality relations and their respective validity. It may thus be useful to conduct analyses of the contingencies of just one industry with regard to the utilization and implementation of open innovation. Also, the firms and the respondents in the sample are all from one country: Germany. Yet, given that open innovation as a theme in innovation management is, regarding its proliferation and awareness today, a global issue, firms may differ
concerning the general application, the level of utilization, and the implementation proficiency of open innovation with regard to the country background. Future studies, therefore, may attempt to generate cross-country data sets. Also the adoption of a more longitudinal approach may bear promise for further insights. Firms may adopt certain organizational approaches to open innovation at one point, learn and gain proficiency over time, and eventually adapt their organizational approaches accordingly, to further improve their open innovation performance.

Our investigation was focused on the effect of firms’ overall openness on innovation performance neglecting, both the differences in sources as well as the differences in their impact on innovation output. A differentiation of knowledge sources may provide further insights into the utilization of external knowledge, the effects for innovation performance, and the appropriate design of organizational structures, culture, and strategy. Utilizing knowledge from universities, for instance, may require different structures and may be more suitable to exploration than to exploitation objectives as opposed to collaborating with customers. Also, both may lead to different innovation results or impact on radical and incremental innovation performance differently. Further, it may be worth investigating to which degree individual sources contribute to the overall innovation performance. Not all sources may be of similar importance and there may be an order of sources and impact strength. And finally, these different sources can be again contingent upon different firm characteristics, and hence require different conditions with regard to organizational structure, culture, or innovation strategy (Bahemia and Squire, 2010, Sofka and Grimpe, 2008).

Regarding the independent variables “search breadth” and “search depth”, it has to be acknowledged that both show correlations of noteworthy magnitude. Relying on the conceptual differentiation of both made by Laursen and Salter (2006), we believe that both represent distinct dimensions of firms’ external knowledge search strategies. This is also confirmed by the fact that the results we obtain differ to a great extent between breadth and depth. Most of the results for organizational structure are found for the breadth dimension only, whereas the strategy analysis mostly finds search depth to be relevant. Still, both dimensions are rather similar with regard to their computation, which most likely is the reason for their correlation. Future research may engage in efforts to detail, specify, and differentiate the concepts of search breadth and depth more. One way to go forward may be the utilization of approaches for measuring the
relationship strength (i.e. search depth) differently than through the (self-reported) assessment of source relevance. Network theory offers a few possible approaches worth considering (e.g. frequency, quality, and stability of relation). Additionally to this and ideally building on a more fine-grained conception of search breadth and depth, future research should investigate further why our results show inconsistent patterns with regard to the contingency conditions of breadth and depth.

Further, our study relied exclusively on subjective performance data. Future research may include more objective performance measures, such as patents for the success of knowledge utilization, or financial performance data for the success of the firm with its innovation activities.

Our research focused on contingency effects of the organizational structure, culture, and strategy. However, it may be necessary to include further contextual contingencies such as environmental and competitive dynamics. Concerning the moderation analysis, the analysis of three-way interactions and the analysis of third variable effects may be another interesting opportunity for further research. The non-significance of some of the variables, for instance decentralization or open mindedness, may be explained by a variable yet uncovered. Furthermore, for this research we adopted an understanding of fit and alignment as bivariate moderation. A possible further approach would be to adopt a more comprehensive understanding of alignment, understanding fit as co-alignment between a variety of variables forming an overall appropriate configuration of organizational elements (Drazin and Van de Ven, 1985; Venkatraman, 1989; Wolf, 2003). Such an approach would call for different methodological approaches, but would provide the opportunity to investigate the interaction of all variables as an overall organizational system (Drazin and Van de Ven, 1985:515; Wolf, 2003:347). This may be reasonable, as different factors may be in complementary or substitutional relation to each other. This applies to the different variables of organizational structure. For instance, there may be an ideal overall configuration of decentralization, formalization, and specialization. But also between the broader factors organizational structure, culture, and strategy, such effects may exist. As our results suggest formalization and connectedness to be relevant, there may be an ideal configuration of elements of organizational structure and culture in a manner in which the structure of an organization would be aligned, i.e. in fit, with its cultural characteristics. Research also shows that exploration and exploitation differ substantially with regard to the required
organizational settings (Jansen et al., 2006). Further research may adopt a more comprehensive view and investigate possible interactions among these variables. In addition, further research may examine the contingency propositions of this study with a multi-methodological lens. A methodological triangulation of different conceptualizations and operationalizations of fit may aid establishing more reliable insights (Venkatraman, 1989:440).

In addition to the adoption of a different conceptual and methodological understanding of fit and alignment, future research may also adopt different levels of investigation. Many organizational phenomena are actually grounded in actions and conditions on the micro or project level (Rothaermel and Hess, 2007; Felin and Foss, 2005). The investigation on project level may enrich the understanding of how and why the factors of this analysis interplay. As to the assumption that some of the results, such as the non-significance of decentralization, may be explained by third variable effects, project level or case study investigations may provide a suitable means to uncover such effects.

Similarly, specialization was found to be rather negative. However this concerns specialization on the organizational or unit level. Future research may incorporate more explicitly the analysis of individual specialists or persons with the responsibility for one specialized task. Though much research on open innovation and its management implications is case-study-based, the explication of certain implications of this study through the means of case-study-based examinations, thereby shedding light onto specific processes and roles that individuals play in the search for and integration of external knowledge, seems to be very promising.

Finally, future research may also differentiate external search according to knowledge type (e.g. tacit or explicit; distant or related). Searching knowledge which is distant from the current knowledge domain may require utilizing different sources on the one hand but may likewise require different organizational structures. Also processes of searching, absorbing, and utilizing knowledge may differ with regard to source and knowledge type. This adds to the suggestion that the investigation of open innovation on other than the firm level may be another fruitful research endeavor.

Despite these limitations and demands for further research, we believe that our study has provided valuable insights for both academic research and management practice. The investigation of firms’ external knowledge search and the contingency conditions for its performance effects adds to theoretical knowledge about firms’ open innovation
activities, and aids managers in their efforts to implement open innovation successfully. The results of our study provide ground for an ongoing and more differentiated examination of the conditions suitable for external knowledge utilization and the interactions between the organizational settings and external knowledge search practices. We confirm that firms benefit from searching widely and deeply for knowledge in their environment and acknowledge the importance of an appropriate alignment of firms’ search efforts and their organizational characteristics. We show that firms have substantial means to increase their potential to benefit from the application of open innovation.
Appendix

Appendix 1: Survey questionnaire

RWTH-Innovationsmonitor: Managementpraktiken für den Innovationserfolg

Ziele

Ihr Nutzen
- Sie wirken mit an den ersten repräsentativen Studien zum Thema, dessen Relevanz auch die Förderung durch die Deutsche Forschungsgesellschaft und das Bundesministerium für Bildung und Forschung zeigt.
- Sie erhalten einen individuellen Benchmarking-Bericht, der für Ihr Unternehmen Erfolgspotenziale aufzeigt für das Innovationsmanagement. Davon profitiert Ihr Unternehmen auch, wenn es derzeit keine eigene Forschung & Entwicklung betreibt.
- Für jede vollständige Teilnahme spenden wir 5 Euro an MISEREOR für aktuelle Projekte.

Hinweise
- Hier können Sie vorab den Fragenkatalog einsehen.
- Ein geeigneter Ansprechpartner sind Sie, wenn Sie einen guten Überblick über die Innovationsaktivitäten Ihres Unternehmens haben.
- Beim Teilnehmen an der Studie ca. 25 Minuten gedauert, die Sie auch in mehreren Etappen absolvieren können.
- Für einige Fragen sind exakte Antworten nur schwer möglich. Hier helfen Ihre subjektiven Schätzungen aber mehr als fehlende Angaben.
- Alle Ihre Angaben werden gegenüber Dritten streng vertraulich und anonym behandelt.
- Bitte nutzen Sie zur Navigation nur die Zurück-/Weiter-Buttons unten auf jeder Seite.

Initiater
Die wissenschaftliche Leitung für dieses Forschungsprojekt hat:

Prof. Dr. Frank T. Piller
Lehrstuhl für Technologie- und Innovationsmanagement
www.lim.rwth-aachen.de

Ich bedanke mich vorab recht herzlich für Ihre Unterstützung
Ihr Prof. Frank Piller
## Innovationsaktivitäten Ihres Unternehmens

Bitte beziehen Sie alle folgenden Fragen nur auf Ihr Unternehmen als rechtlich selbständige Einheit. Schließen Sie rechtlich selbständige Mutter- oder Tochtergesellschaften Ihres Unternehmens bitte aus.

### Wie hoch war der Anteil von Mitarbeitern in Ihrem Unternehmen mit naturwissenschaftlichem bzw. technischem Hochschulabschluss im Durchschnitt der Jahre 2007-2009?

(Falls Sie es nicht exakt wissen, geben Sie bitte eine Schätzung an.)

% der Mitarbeiter

### Hat Ihr Unternehmen in den drei Jahren von 2007 bis 2009 Forschungs- & Entwicklung- (F&E) Aktivitäten selbst durchgeführt?

<table>
<thead>
<tr>
<th></th>
<th>nein</th>
<th>gelegentlich, wenn ein technisches Problem zu lösen war</th>
<th>kontinuierlich, durch festa F&amp;E-Abteilungen bzw. Mitarbeiter</th>
</tr>
</thead>
</table>

### Hat Ihr Unternehmen in den drei Jahren von 2007 bis 2009 F&E-Leistungen von extern zugekauft?

<table>
<thead>
<tr>
<th></th>
<th>nein</th>
<th>ja</th>
</tr>
</thead>
</table>

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## Innovationsaktivitäten Ihres Unternehmens

Falls Sie es keine exakten Angaben machen können, geben Sie bitte eine Schätzung an.

### Wie hoch waren im Durchschnitt der drei Jahre 2007 bis 2009 die Jahresausgaben für interne F&E-Aktivitäten, d.h. F&E-Aktivitäten, die Ihr Unternehmen selbst durchgeführt hat?

% vom Jahresumsatz

### Wie hoch waren im Durchschnitt der drei Jahre 2007 bis 2009 die Jahresausgaben für externe F&E-Aktivitäten, d.h. F&E-Aktivitäten, die Ihr Unternehmen nicht selbst durchgeführt, sondern eingekauft hat?

% vom Jahresumsatz

### Wie viele F&E-Standorte gab es in Ihrem Unternehmen durchschnittlich in den Jahren 2007-2009?

Standorte

### Wie viele F&E-Mitarbeiter gab es in Ihrem Unternehmen durchschnittlich in den Jahren 2007-2009?

Mitarbeiter

**Hinweis für die folgende Frage:** Produkt- oder Prozessinnovationen, die Ihr Unternehmen am Markt eingeführt hat, müssen nicht notwendigerweise auch (vollständig) von Ihrem Unternehmen entwickelt worden sein.

### Hat Ihr Unternehmen in den drei Jahren von 2007-2009 neue oder substantiell verbesserte Produkte am Markt eingeführt?

<table>
<thead>
<tr>
<th></th>
<th>nein</th>
<th>ja</th>
</tr>
</thead>
</table>

### Hat Ihr Unternehmen in den drei Jahren von 2007-2009 neue oder substantiell verbesserte Prozesse zur Herstellung bzw. zum Vertrieb Ihrer Produkte eingeführt?

|   | nein | ja |
### Innovationsaktivitäten Ihres Unternehmens

<table>
<thead>
<tr>
<th>Frage</th>
<th>Ja</th>
<th>Nein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hat Ihr Unternehmen in den drei Jahren von 2007-2009 Produktinnovationen am Markt eingeführt, die neu waren ...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gegen über den bisherigen Produkten Ihres Unternehmens und Ihrer Wettbewerber im Markt?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>contra den bisherigen Produkten Ihres Unternehmens, nicht aber gegenüber den bisherigen Produkten Ihrer Wettbewerber?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In 2007-2009 eingeführte Produkte, die neu waren gegenüber den bisherigen Produkten Ihres Unternehmens und Ihrer Wettbewerber im Markt.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In 2007-2009 eingeführte Produkte, die neu waren gegenüber den bisherigen Produkten Ihres Unternehmens, nicht aber denen Ihrer Wettbewerber.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In 2007-2009 eingeführte Produkte, die nicht neu, aber substantiell verbessert waren gegenüber den bisherigen Produkten Ihres Unternehmens.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In 2007-2009 unveränderte bzw. nur geringfügig veränderte Produkte (einschließlich des Weiterverkäufs von eingekauften Produkten).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hat Ihr Unternehmen in den drei Jahren 2007-2009 Prozessinnovationen für Produktions- bzw. -vertrieb eingeführt, die ...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>neu waren gegenüber den bisherigen Prozessen Ihres Unternehmens und Ihrer Wettbewerber im Markt?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>für die Markteinführung Ihrer neuen Produkte notwendig waren?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>zu einer Qualitätsverbesserung Ihrer bisherigen Produkte geführt haben?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>zu einer Stückkostenreduktion Ihrer bisherigen Produkte geführt haben?</td>
<td></td>
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</tr>
</tbody>
</table>

### Innovationsziele Ihres Unternehmens

<table>
<thead>
<tr>
<th>Frage</th>
<th>Keine Bedeutung</th>
<th>geringe Bedeutung</th>
<th>mittlere Bedeutung</th>
<th>hohe Bedeutung</th>
</tr>
</thead>
<tbody>
<tr>
<td>In den letzten drei Jahren mehr neue bzw. substantiell verbesserte Produkte eingeführt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>einen höheren Umsatzanteil aus Produkten generiert, die in den letzten drei Jahren neu entwickelt bzw. substantiell verbessert wurden</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in den letzten drei Jahren mehr neue bzw. substantiell verbesserte Prozesse für Produktions- bzw. -vertrieb eingeführt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wie hoch war die Bedeutung der folgenden Innovationsziele Ihres Unternehmens in den Jahren 2007-2009?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erweiterung der Produktpalette</td>
<td></td>
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</tr>
<tr>
<td>Erschließung neuer Märkte</td>
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<tr>
<td>Erhöhung von Markanteilen</td>
<td></td>
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<tr>
<td>Verbesserung der Qualität bestehender Produkte</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Ersetzen von veralteten Produkten</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steigerung der Flexibilität in der Produktion</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Reduktion der Herstellungskosten</td>
<td></td>
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<tr>
<td>Einhaltung gesetzlicher Bestimmungen</td>
<td></td>
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<tr>
<td>Reduktion von Umweltbelastungen</td>
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</tbody>
</table>
### Aufnahme von Information und Wissen aus externen Quellen

#### Welche Bedeutung hatten die folgenden externen Akteure als Informations- und Wissensquelle im Rahmen der Innovationsaktivitäten Ihres Unternehmens in den Jahren 2007-2009?

<table>
<thead>
<tr>
<th>Akteur</th>
<th>nicht wichtig/nicht genutzt</th>
<th>geringe Bedeutung</th>
<th>mittlere Bedeutung</th>
<th>hohe Bedeutung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andere Einheiten innerhalb Ihres eigenen Unternehmens/-verbundes</td>
<td></td>
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</tr>
<tr>
<td>Zulieferer</td>
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<tr>
<td>Kunden</td>
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<tr>
<td>Wettbewerber oder andere Firmen Ihrer Branche</td>
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<tr>
<td>Private Unternehmen, Institute, Labore für Forschung &amp; Entwicklung</td>
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<tr>
<td>Consultants oder spezielle Dienstleister im Bereich Innovation (z.B. IDEO, Innocentive, NineSigma etc.)</td>
<td></td>
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<tr>
<td>Universitäten oder Fachhochschulen</td>
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<tr>
<td>Öffentliche Forschungsinstitute oder spezielle Behörden (z.B. für Regulierung, Umwelt, Sicherheit, Standards)</td>
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### Aufnahme von Information und Wissen aus externen Quellen

#### Welche formalen F&E-Kooperationen bestanden zwischen Ihrem Unternehmen und externen Informations- und Wissens trägern in den Jahren 2007-2009 - differenziert nach geografischer Reichweite?

Eine formale F&E-Kooperation ist eine vertraglich geregelt Zusammenarbeit, in der die Partner Aufwand, Kosten und/oder Ergebnisse im Halbufl auf ein gemeinsames Innovationsvorhaben teilen.

Mehrfachnennungen möglich!

<table>
<thead>
<tr>
<th>Akteur</th>
<th>innerhalb der Region</th>
<th>innerhalb Deutschlands</th>
<th>innerhalb Europas</th>
<th>außerhalb Europas</th>
<th>keine F&amp;E-Kooperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andere Einheiten innerhalb Ihres eigenen Unternehmens/-verbundes</td>
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</tr>
<tr>
<td>Zulieferer</td>
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<td>Kunden</td>
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<td>Wettbewerber oder andere Firmen Ihrer Branche</td>
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<td>Universitäten oder Fachhochschulen</td>
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<tr>
<td>Öffentliche Forschungsinstitute oder spezielle Behörden (z.B. für Regulierung, Umwelt, Sicherheit, Standards)</td>
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</table>
**Aufnahme von Information und Wissen aus externen Quellen**

### Welche weiteren Kanäle waren in den Jahren 2007-2009 für den Zugang zu externen Informations- und Wissensquellen von Bedeutung für Ihr Unternehmen?

- **Kauf-/Lizenzverträge** z.B. über F&E-Leistungen, Patente, Maschinen, Hardware, Software oder Firmenakquisitionen
- **Offizielle Events** z.B. Messen, Ausstellungen, Konferenzen, Fachtagungen, Workshops, Industrieverbandsrefren
- **Informelle Kontakte** z.B. persönliche Geschäftsbeziehungen
- **Öffentliche Information** z.B. Patente, Publikationen, Geschäftsberichte, Internetdatenbanken

Mehrfachnennungen möglich!

<table>
<thead>
<tr>
<th>Andere Enthaltene innerhalb ihres eigenen Unternehmens/verbundes</th>
<th>Kauf-/Lizenzverträge</th>
<th>Offizielle Events</th>
<th>Informelle Kontakte</th>
<th>Öffentliche Information</th>
<th>keine dieser Kanäle</th>
</tr>
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<tbody>
<tr>
<td>Zulieferer</td>
<td></td>
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<td>Kunden</td>
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<tr>
<td>Wettbewerber oder andere Firma Ihrer Branche</td>
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<tr>
<td>Private Unternehmen, Institute, Labore für Forschung &amp; Entwicklung</td>
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<tr>
<td>Consultants oder spezielle Dienstleister im Bereich Innovation (z.B. IDEO, Innovative, NineSigma etc.)</td>
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<tr>
<td>Öffentliche Forschungsanstaltien oder spezielle Behörden (z.B. für Regulierung, Umwelt)</td>
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Zurück | Weiter

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**Aufnahme von Information und Wissen aus externen Quellen**

### Wie häufig nutzte Ihr Unternehmen in den Jahren 2007-2009 für die eigenen Innovationsaktivitäten externes Wissen in den folgenden Formen?

- Generelle Erkenntnisse aus der Grundlagenforschung
- Ideen für neue Produkte oder Prozesse
- Ausgearbeitete und verifizierte Konzepte
- Prototypisch umgesetzte Komponenten, Produkte oder Technologien
- Unter Realbedingungen getestete Komponenten, Produkte oder Technologien

<table>
<thead>
<tr>
<th>Gab es in Ihrem Unternehmen in den Jahren 2007-2009 Mitarbeiter oder Abteilungen, die sich speziell mit der externen Wissenssuche befasst haben?</th>
</tr>
</thead>
<tbody>
<tr>
<td>nein, keine spezialisierten Mitarbeiter oder Abteilungen</td>
</tr>
</tbody>
</table>

### Wie hoch war der Anteil der Innovationsprojekte, die in den Jahren 2007-2009, bei denen die Integration externen Wissens substanzial zum Projekterfolg beigetragen hat?

<table>
<thead>
<tr>
<th>&lt; 10%</th>
<th>10-40%</th>
<th>41-60%</th>
<th>61-90%</th>
<th>&gt; 90%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Zurück | Weiter
Zusammenarbeit mit Universitäten, Fachhochschulen und öffentlichen Forschungseinrichtungen

Welche Bedeutung hatten die folgenden Formen der Zusammenarbeit mit Universitäten, Fachhochschulen und öffentlichen Forschungseinrichtungen in den Jahren 2007-2009?

<table>
<thead>
<tr>
<th>Form der Zusammenarbeit</th>
<th>nicht genutzt / nicht wichtig</th>
<th>geringe Bedeutung</th>
<th>mittlere Bedeutung</th>
<th>hohe Bedeutung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kauf / Lizenzierung von Technologien</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gemeinsam durchgeführte Forschungs- und Entwicklungsprojekte</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vergabe von Forschungsaufträgen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vergabe von Beratungsaufträgen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Einstellung von Absolventen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weiterbildung Ihrer Mitarbeiter an Universitäten etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diplom-, Doktor- oder Abschlussarbeiten mit Ihren Unternehmen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teilnahme an wissenschaftlichen Konferenzen und Workshops</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informelle Kontakte zu Mitarbeitern von Universitäten etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Zusammenarbeit mit Universitäten, Fachhochschulen und öffentlichen Forschungseinrichtungen

Wie hoch war die Bedeutung der folgenden Ziele der Zusammenarbeit mit Universitäten, Fachhochschulen und öffentlichen Forschungseinrichtungen im Rahmen der Innovationsaktivitäten Ihres Unternehmens in den Jahren 2007-2009?

<table>
<thead>
<tr>
<th>Ziel der Zusammenarbeit</th>
<th>keine Bedeutung</th>
<th>geringe Bedeutung</th>
<th>mittlere Bedeutung</th>
<th>hohe Bedeutung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kontakte und langfristige Beziehungen zu profilierten Forschern</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kenntnis neuer, grundlegender Forschungsergebnisse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exploration neuer Technologie- und Forschungsfelder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gemeinsame wissenschaftliche Publikationen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entwicklung patentierbarer Technologien</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zugang zu spezifischen Instrumenten und Techniken für den F&amp;E-Prozess</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entwicklung konkreter Prototypen und Produktdesigns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ausgleich von eigenen F&amp;E-Kapazitätsengpässen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kostenreduktion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduktion der Time-to-Market</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Zusammenarbeit mit Universitäten, Fachhochschulen und öffentlichen Forschungseinrichtungen

<table>
<thead>
<tr>
<th>Forschungsergebnisse zu theoretisch</th>
<th>keine Bedeutung</th>
<th>geringe Bedeutung</th>
<th>mittlere Bedeutung</th>
<th>hohe Bedeutung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keine personelle und finanzielle Unterstützung im eigenen Unternehmen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keine geeignete öffentliche Förderung einer solcher Zusammenarbeit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zu große räumliche Distanz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keine geeigneten Partner zu finden</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zu wenig Information über deren Forschungsaktivitäten</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zu langer Zeitraum der Forschungsaktivitäten</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zu schnelle Veröffentlichung der Forschungsergebnisse</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zu schwere Eingang über Verwaltungskosten</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zu verschiedene Arbeitsweisen und Prioritäten</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Weitergabe bzw. Offenlegung von Information und Wissen nach außen

Neben der Aufnahme von Information und Wissen aus externen Quellen kann es für ein Unternehmen auch nützlich sein, Information und Wissen zielgerichtet an externe Dritte weiterzugeben bzw. allgemein offenlegen.

<table>
<thead>
<tr>
<th>Zusätzliche Einnahmen generieren durch Kommerzialisierung eigenen Wissens</th>
<th>keine Bedeutung</th>
<th>geringe Bedeutung</th>
<th>mittlere Bedeutung</th>
<th>hohe Bedeutung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patentierung durch Wettbewerber verhindern</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eigene Innovationskompetenz signalisieren</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neuen Innovationspartner finden</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problemlösungsprozesse mit bestehenden Partnern verbessern</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Externe ebenfalls zur Weitergabe bzw. Offenlegung ihres Wissens verlassen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Von der Weiterentwicklung eigener Produkte und Prozesse durch externe profitieren</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Entwicklung von Komplementär-Produkten durch externe beschleunigen</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Verbreitung eigener Produkte im Markt beschleunigen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beitrag zur Etablierung von Industriestandards leisten</td>
<td></td>
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</tr>
</tbody>
</table>
### Weitergabe bzw. Offenlegung von Information und Wissen nach außen:

<table>
<thead>
<tr>
<th>Formale Zusammenarbeit in F&amp;E-Kooperationen</th>
<th>nicht wichtig/nicht genutzt</th>
<th>geringe Bedeutung</th>
<th>mittlere Bedeutung</th>
<th>hohe Bedeutung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informelle Kontakte und Persönliche Beziehungen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Öffentliche Kanäle/Foren:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Eigene Patente</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Veröffentlichung in Zeitschriften, White Papers und Geschäftsberichten</td>
<td></td>
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</tr>
<tr>
<td>Veröffentlichung von Software Source Code</td>
<td></td>
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</tr>
<tr>
<td>Vorträge auf Fachtagungen und Konferenzen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Präsentationen auf Messen und Ausstellungen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marktransaktionen:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verkauf und Auskoppelung von Technologien/Patenten</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akquisition von F&amp;E-Auftragen</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Personalausleihen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ausgründungen bzw. Verkauf von Unternehmensbereichen</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Schutz von Wissen

<table>
<thead>
<tr>
<th>Rechtliche Maßnahmen:</th>
<th>nicht wichtig/nicht genutzt</th>
<th>geringe Bedeutung</th>
<th>mittlere Bedeutung</th>
<th>hohe Bedeutung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patentierung</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copyrights</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trademarks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertragsvereinbarung mit externen Partnern (zum geistigen Eigentum, z.B. Non-disclosure agreements)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organisatorische Maßnahmen:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formale interne Regeln für die Kommunikation nach außen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spezielle interne Abteilungen für Kontrolle und Schutz von Wissen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strategische Maßnahmen:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schnelle Markteinführung von Innovationen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Komplex, schwer zu imitierende Produktionsdesigns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strikt Geheimhaltung</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Organisation der Innovationsaktivitäten Ihres Unternehmens

Inwieweit stimmen Sie den folgenden Aussagen über die Organisation Ihrer betrieblichen Innovationsaktivitäten in den Jahren 2007-2009 zu?

<table>
<thead>
<tr>
<th>Unsere Innovationsaktivitäten waren organisatorisch stark getrennt von anderen Aktivitäten (z.B. Marketing, Vertrieb, oder Produktion).</th>
</tr>
</thead>
<tbody>
<tr>
<td>stimme gar nicht zu</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unsere Innovationsaktivitäten gliederten sich in einzelne Bereiche, die organisatorisch stark getrennt waren (z.B. nach Grundlagen- und Anwendungsorientierung, nach Regionen oder Produkten).</th>
</tr>
</thead>
<tbody>
<tr>
<td>stimme gar nicht zu</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unsere Innovationsaktivitäten basierten auf streng formalisierten Prozessschritten und detaillierten Aufgabenbeschreibungen.</th>
</tr>
</thead>
<tbody>
<tr>
<td>stimme gar nicht zu</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wer traf in den Jahren 2007-2009 üblicherweise in den folgenden Situationen die Entscheidung?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priorisierung von Innovationsvorhaben</td>
</tr>
<tr>
<td>Koordination des Ablaufs von Innovationsvorhaben</td>
</tr>
<tr>
<td>Verteilung von einzelnen Innovationsaufgaben</td>
</tr>
<tr>
<td>Einsatz von Innovationsmethoden, -verfahren und -instrumenten</td>
</tr>
</tbody>
</table>

Instrumente und Methoden des Technologie- und Innovationsmanagements

Welche der folgenden Instrumente und Methoden hat Ihr Unternehmen in den Jahren 2007-2009 eingesetzt?

- Nutzerverfahren
- Technologieportfolioanalyse
- Strategische Technologiefrühauflklärung
- Benchmarking
- Szenariobewertung
- SWOT-Analyse
- Investitionsrechnung
- Patentanalyse
- Delphi-Methode
- Cross-Impact-Analyse
- Lebenszyklusanalyse
- Quality Function Deployment
- Brainstorming-/writing
- Mindmapping
- TRIZ Methode
- dedizierte Verfahren zur Ideen- und Konzeptbewertung
- keines dieser Instrumente
### Management von Innovationsprojekten

**Wie hoch war die durchschnittliche technische Komplexität der Innovationsprojekte Ihres Unternehmens in den Jahren 2007-2009?**

- sehr niedrig
- selten
- manchmal
- oft
- sehr oft

**Wie häufig kamen in den Jahren 2007-2009 folgende Managementansätze im Rahmen von Innovationsprojekten zum Einsatz?**

<table>
<thead>
<tr>
<th>Option</th>
<th>nie</th>
<th>selten</th>
<th>manchmal</th>
<th>oft</th>
<th>sehr oft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detaillierte Ablaufplanung und Risikoanalyse zu Beginn von Innovationsprojekten</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible Gestaltung von Innovationsprojekten, um auf unvorhergesehene Umstände zu reagieren</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gesicherter Zeit- und Ressourceneinsatz, um unvorhergesehene Einkaufsfehler auf den Projekterfolg zu verursachen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel- bzw. sequenzielle Entwicklung von mehreren Lösungsalternativen, von denen im Weiteren die beste ausgewählt wird</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Management von Innovationsprojekten

**Wie viele Lösungsalternativen, die Ihr Unternehmen im Rahmen der Innovationsprojekte in 2007-2009 generiert, aber nicht weiterverfolgt hat, wurden durch die folgenden Bewertungs- und Teststufen eliminiert?**

<table>
<thead>
<tr>
<th>Bewertungs- und Teststufe</th>
<th>keine/ sehr wenige Lösungsalternativen eliminiert</th>
<th>sehr viele Lösungsalternativen eliminiert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durch Idrenbewertung wurden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durch Konzepttests wurden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durch Prototypentests wurden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durch Produkt- bzw. Marktttest wurden</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Welche der folgenden Ansätze und Instrumente, um mit neuen Ideen und Technologien zu experimentieren, hat Ihr Unternehmen in den Jahren 2007-2009 eingesetzt?**

- [ ] Produktklinik
- [ ] Reverse Engineering
- [ ] Computer Aided Design
- [ ] Rapid Prototyping
- [ ] Finite Elemente Methode
- [ ] Computer Simulation
- [ ] Virtual Prototyping
- [ ] High Throughput Screening
- [ ] keines dieser Instrumente
**Maßnahmen zur Innovationsförderung**

Welche Bedeutung hatten in den Jahren 2007 - 2009 die folgenden Maßnahmen für die Förderung von Innovationsaktivitäten in Ihrem Unternehmen?

<table>
<thead>
<tr>
<th>Maßnahme</th>
<th>nicht wichtig/nicht gemacht</th>
<th>geringe Bedeutung</th>
<th>mittlere Bedeutung</th>
<th>hohe Bedeutung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovationszirkel/-arbeitskreise</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plattformen zur Sammlung von Ideen und Vorschlägen der Mitarbeiter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immatenelle Anreize für innovationsbezogene Leistungen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materielle bzw. finanzielle Anreize für innovationsbezogene Leistungen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zielvereinbarungen bezüglich innovationsbezogener Leistungen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gezielte Job-Rotation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innovationsbezogene Fortbildungs- und Trainingsmaßnahmen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finden, Fördern und Binden von Schlüsselpersonen, die Innovationen vorantreiben (z.B. Katalysatoren, Promotoren)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vereinbarte Arbeitszeit zur freien Verwendung auf neue Ideen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interdisziplinäre bzw. funktionsübergreifende Teams</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Zurück** **Weiter**

---

**Interne Kommunikation**

Rückblickend auf die Jahre 2007 - 2009: Inwieweit stimmen Sie den folgenden Aussagen über die interne Kommunikation in Ihrem Unternehmen zu?

<table>
<thead>
<tr>
<th>Aussage</th>
<th>stimme gar nicht zu</th>
<th>stimme nicht zu</th>
<th>stimme zu</th>
<th>stimme voll zu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsere Mitarbeiter bevorzugten sehr häufig interne gegenüber externen Wissensquellen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsere Mitarbeiter behandelten interne und externe Wissensquellen stets gleichwertig, entscheidend war die Qualität.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manager in unserem Unternehmen nahmen es Ihren Mitarbeitern nicht übel, wenn ihre Sichtweise in Frage gestellt wurde.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In unserem Unternehmen wurden Fehler toleriert und als Lernmöglichkeit angesehen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manager in unserem Unternehmen motivierten Mitarbeiter, über den Tellerrand zu sehen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In unserem Unternehmen konnte man zu jedem Kollegen, unabhängig von Gang oder Position, leicht Kontakt aufnehmen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informelle Gespräche auf dem Weg zwischen Mitarbeitern unterschiedlicher Abteilungen waren in unserem Unternehmen alltäglich.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Zurück** **Weiter**
Abschließende Fragen zu Ihrem Unternehmensumfeld

Rückblickend auf die Jahre 2007-2009, wie beurteilen Sie die technologische Veränderung in Ihrem Markt?

- stabil, vorhersehbar
- 
- dynamisch, unsicher

Rückblickend auf die Jahre 2007-2009, wie beurteilen Sie die Veränderung von Kundenanforderungen in Ihrem Markt?

- stabil, vorhersehbar
- 
- dynamisch, unsicher

Rückblickend auf die Jahre 2007-2009, wie beurteilen Sie die Wettbewerbsintensität in Ihrem Markt?

- sehr niedrig
- 
- sehr hoch

Rückblickend auf die Jahre 2007-2009, wie stark hat die aktuelle Wirtschaftskrise die Innovationsaktivitäten Ihres Unternehmens eingeschränkt?

- überhaupt nicht eingeschränkt
- 
- überaus stark eingeschränkt

Zurück Weiter

Herzlichen Dank für Ihre Unterstützung!

Wenn Sie auf Basis dieser Studie einen individualisierten Benchmarking-Bericht für Ihr Unternehmen erhalten wollen, geben Sie uns bitte Ihre E-Mail-Adresse an:

Wir möchten an dieser Stelle noch einmal darauf hinweisen, dass Ihre Angaben gegenüber Dritten streng vertraulich und anonym behandelt werden.

Haben Sie Interesse an einer qualitativen Folgeuntersuchung der Strukturen und Abläufe Ihres Unternehmens bei der Integration externen Wissens, um detaillierte Managementselbsteinschätzungen abzuleiten zu können?

- Ja
- Nein

Ansprechpartner bei Rückfragen

Dr. Jan Christoph IN
Philipp Wagner

RWTH Aachen
Lehrstuhl für Technologie- und Innovationsmanagement
Templergraben 64
52062 Aachen

Tel.: +49-241-8092367
Fax: +49-241-8092367
E-Mail: info@tim.rwth-aachen.de
E-Mail: wagner@tim.rwth-aachen.de
http://tim.rwth-aachen.de

Zurück Weiter

Vielen Dank für Ihre Unterstützung des RWTH Innovationsmonitors!

Fenster schließen
Einladung zur Umfrage im Forschungsprojekt RWTH-Innovationsmonitor

Sehr geehrte(r) Frau / Herr XYZ,

vielen Dank für Ihr grundsätzliches Interesse an einer Teilnahme an unserem Forschungsprojekt RWTH-Innovationsmonitor.

Ziel dieses Projekts und der Umfrage, ist die Identifikation von Managementansätzen und -praktiken zur Steigerung der Innovationsfähigkeit und letztlich des Innovationserfolgs von Unternehmen.


Unsere Studie richtet sich primär an Personen des Managements mit Bezug zu Themen und Fragestellungen aus den Bereichen Innovationsmanagement, Neuproduktentwicklung, oder Forschung und Entwicklung. Aufgrund Ihrer Erfahrung und Position innerhalb der Firma XYZ, möchten wir Sie hiermit bitten, uns im Rahmen der Untersuchung RWTH-Innovationsmonitor Auskunft zu geben bezüglich Themen der Unternehmenskultur, Organisationsstrukturen, Personalmanagement und F&E-Projektmanagement.

Wir versichern Ihnen absolute Vertraulichkeit im Hinblick auf Ihre Angaben und deren Verwendung dient einzig wissenschaftlichen Zwecken.

Erfahrungsgemäß benötigt die Beantwortung der Umfrage 25-30 Minuten, die sich auch etappenweise erledigen lässt, und ebenso Vorteile für Sie birgt:

- Sie haben Gelegenheit, einen Beitrag zu einer wesentlichen Forschungsarbeit zu leisten, welche die Diskussion um das Konzept Open Innovation nachhaltig prägen soll. Unser Forschungsvorhaben wird unterstützt durch die Deutsche Forschungsgesellschaft (DFG) und dem Bundesministerium für Bildung und Forschung (BMBF).
- Sie erhalten einen individuellen Benchmarking-Bericht für Ihr Unternehmen, der Aufschluss gibt über Ihren Öffnungsgrad relativ zu Unternehmen Ihrer Branche sowie Empfehlungen zu komplementären Management- und Organisationspraktiken, durch die Ihr Unternehmen mehr von Open Innovation-Strategien profitieren kann.
- Zudem spenden wir für jede Teilnahme an unserer Studie 5€ an MISEREOR.
Für weitere Information sowie für die Teilnahme an der Umfrage folgen Sie bitte dem Link: #######

Sollten Sie weitere Fragen zu dieser Forschungsarbeit haben, stehen Ihnen meine Mitarbeiter Christoph Ihl (#######) und Philipp Wagner (#######) gerne jederzeit zur Verfügung.

Nochmals vielen Dank für Ihre Unterstützung dieses Forschungsprojekts, an das wir große Erwartungen legen.

Mit freundlichen Grüßen

Professor Dr. Frank Piller
Dr. Christoph Ihl
Philipp Wagner
Erstes Erinnerungsschreiben: Einladung zur Umfrage im Forschungsprojekt RWTH-Innovationsmonitor

Sehr geehrte(r) Frau / Herr XYZ,

wir möchten Sie hiermit gerne an unser Schreiben bezüglich der Umfrage RWTH-Innovationsmonitor vom xx.xx.xxxx erinnern und Sie um Ihre Unterstützung und Teilnahme hierbei bitten.

Wir konnten bisher bereits die Teilnahme zahlreicher Unternehmen und Manager verzeichnen, jedoch freuen wir uns nach wie vor über jede weitere Auskunft, welche die Qualität und Validität unserer späteren Erkenntnisse stärken wird. Ebenso profitieren Sie von einer größeren Informationsbasis, denn diese ermöglicht die valide Erstellung eines Benchmarking.


Wir freuen uns über Ihre Teilnahme und stehen Ihnen bei Fragen zur Studie und Umfrage auch gerne persönlich zur Verfügung. Bitte wenden Sie sich hierfür gerne an meine Mitarbeiter Christoph Ihl (#######) und Philipp Wagner (########).

Weitere Information sowie den Zugang zur Umfrage finden Sie unter diesem Link: #######

Mit freundlichen Grüßen

Professor Dr. Frank Piller
Dr. Christoph Ihl
Philipp Wagner
Zweites Erinnerungsschreiben: Einladung zur Umfrage im Forschungsprojekt RWTH-Innovationsmonitor

Sehr geehrte(r) Frau / Herr XYZ,

wir möchten Sie hiermit gerne an unser Schreiben vom xx.xx.xxx sowie unser Telefonat vom xx.xx.xxx bezüglich der Umfrage RWTH Aachen Innovationsmonitor erinnern. Im Rahmen der Studie RWTH-Innovationsmonitor untersuchen wir die Voraussetzungen für erfolgreiche Innovation und wir möchten Sie um Ihre Unterstützung und Teilnahme hierbei bitten.

Im Mittelpunkt steht das immer wichtiger werdende Thema Open Innovation, also die Nutzung externen Wissen zur Steigerung der Innovationsfähigkeit von Unternehmen. Externe Quellen können mit ihrem Wissen einen erheblichen Beitrag hierbei leisten, jedoch brauchen Unternehmen auch entsprechende Fähigkeiten und Prozesse, um dieses Potential erfolgreich zu nutzen. Die Identifikation dieser stellt einen zentralen Erfolgsbestandteil dar. Um hier zu relevanten Erkenntnissen zu kommen richten wir uns mit unserer Studie an Personen aus den Bereichen Innovationsmanagement, Neuproduktentwicklung, oder Forschung und Entwicklung und zielen auf Aspekte der internen Organisation des Innovationsmanagement ab.


Wir freuen uns über Ihre Teilnahme und stehen Ihnen bei Fragen zur Studie und Umfrage auch gerne persönlich zur Verfügung. Bitte wenden Sie Sich hierfür gerne an meine Mitarbeiter Christoph Ihl (#######) und Philipp Wagner (#####).

Weitere Information sowie den Zugang zur Umfrage finden Sie unter diesem Link: #######

Sollten Sie nicht an der Studie teilnehmen wollen, möchten wir die erneute Anfrage zu entschuldigen bitten.

Mit freundlichen Grüßen

Professor Dr. Frank Piller
Dr. Christoph Ihl
Philipp Wagner
Appendix 3: Investigation of sample for non-response-bias

Comparison of respondents and non-respondents

<table>
<thead>
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<th>Variable</th>
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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01

Comparison of late and early-respondents

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</table>

Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01
Appendix 4: Measures overview

Organizational structure

Specialization (based on Gibson and Birkinshaw, 2004; Volberda 1996, 1998)

Innovation activities in our company were separated into different functional areas (e.g. basic research, application-oriented research/development; products; regions).

(1 = strongly disagree, 5 = strongly agree)

Separation (based on Gibson and Birkinshaw, 2004; Volberda 1996, 1998)

Innovation activities in our company were structurally separated from other functions (e.g. Marketing, Sales, Production).

(1 = strongly disagree, 5 = strongly agree)

Formalization (adapted from Desphandé and Zaltman, 1982; Jansen et al., 2005; Pertusa-Ortega et al, 2010)

Innovation activities in our company were based on strict process steps and detailed task descriptions.

(1 = strongly disagree, 5 = strongly agree)

Decentralization (adapted from Mahr and Kretschmer, 2009) (α = 0.723)

At which levels decisions regarding the following aspects were usually made?

The prioritization of innovation projects
The coordination of innovation projects
The allocation of specific innovation tasks
The utilization of specific innovation methods, -procedures and –instruments

(1 = team members, 2 = team leader, 3 = head of department, 4 = top management level)

Organizational culture

Open mindedness (adapted from Baker and Sinkula, 1999) (α = 0.772)

Managers in our firm did not resent their opinions being contested by their employees.
In our firm mistakes were tolerated and seen as learning opportunity.
Managers in our firm motivated employees to think outside the box.

(1 = strongly disagree, 5 = strongly agree)

32 Measure validity was assessed using Cronbach’s alpha (Cronbach, 1951) when applicable.
**Internal connectedness** (adapted from Jaworski and Kohli, 1993) \( (\alpha = 0.714) \)

In our firm it was easy to always approach colleagues irrespective of their hierarchical position.
Informal conversations among employees of different units and departments were a usual occurrence in our firm.

\( (1 = \text{strongly disagree}, 5 = \text{strongly agree}) \)

**NIH** (adapted from Herzog, 2008) \( (\alpha = 0.423) \)

Our employees very often favored internal to external knowledge. (R)
Our employees treated external and internal knowledge always similar, crucial was the respective quality.

\( (1 = \text{strongly disagree}, 5 = \text{strongly agree}) \)

---

**Innovation strategy**

**Exploration** (adapted from He and Wong, 2004) \( (\alpha = 0.537) \)

- Extend product range
- Open up new markets
- Increase of market share

**Exploitation** (adapted from He and Wong, 2004) \( (\alpha = 0.56) \)

- Improve existing product quality
- Exchange of old products
- Improve of production flexibility
- Reduce production costs

\( (1 = \text{no importance}, 4 = \text{high importance}) \)

---

**External Search**

**Breadth** (adapted from Laursen and Salter, 2006)

- Other internal units
- Suppliers
- Customers
- Competitors
- Private research institutes and commercial laboratories
- Universities and other higher education institutions
- Public research institutes
- Consultants and open innovation intermediaries (e.g. Innocentive, NineSigma etc.)
- Public information (e.g. patent disclosures, industry specific literature, scientific publications, company reports etc.)
- Official events (e.g. exhibitions and fairs, professional workshops and conferences, trade associations etc.)
(Breadth is measured by the amount of sources used)

**Depth** (adapted from Laursen and Salter, 2006)

*Depth is the amount of sources being assigned high importance. Source importance is evaluated from on a scale 0 = not important / not used to 3 = high importance.*

---

**Innovation performance**

*NEW* (radical innovation performance)

Share of turnover from products new to the market and products new to the firm.

*IMPR* (incremental innovation performance)

Share of turnover from products that were significantly improved.

*INN* (overall innovation performance)

Share of turnover from incremental as well as radical innovations.
Appendix 5: Descriptive statistics and bivariate correlation tables for the analyses

I: Analysis of external search and innovation performance

Descriptive statistics for the analysis of external search breadth and depth

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Bivariate correlations for the analysis of external search breadth and depth

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II: Analysis of the moderation effects of organizational structure

Descriptive statistics for the analysis of organizational structure variables

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Bivariate correlations for the analysis of organizational structure variables

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Appendix 6: Predicted relationship and partial effects of search breadth on incremental and radical innovation performance
(1) Upper & lower confidence interval
(2) Average predicted effect

(1) Upper & lower confidence interval
(2) Average partial effect
Appendix 7: Predicted relationship and partial effects of search depth on incremental and radical innovation performance
(1) Upper & lower confidence interval

(2) Average predicted effect
Appendix 8: Statistical significance of partial effects by degree of specialization
Appendix 9: Statistical significance of partial effects by degree of separation
Level of partial effect of external search breadth on overall innovation performance at high separation

- (1) Upper & lower confidence interval
- (2) Average partial effect

Level of partial effect of external search breadth on overall innovation performance at very high separation

- (1) Upper & lower confidence interval
- (2) Average partial effect
Appendix 10: Statistical significance of partial effects by degree of formalization
Appendix 11: Statistical significance of partial effects by degree of internal connectedness for search breadth and incremental innovation performance
Appendix 12: Statistical significance of partial effects by degree of “not-invented-here” for search depth and overall innovation performance
Appendix 13: Analysis of marginal effects for search depth and breadth with regard to radical innovation performance

Level of partial effect of external search depth for radical innovation performance by degree of "not-invented-here"-attitudes

Level of partial effect of external search breadth for radical innovation performance by degree of "not-invented-here"-attitudes
Appendix 14: Statistical significance of partial effects by degree of “not-invented-here” for search depth and radical innovation performance
Appendix 15: Statistical significance of partial effects by degree of “not-invented-here" for search breadth and radical innovation performance
## Appendix 16: Tobit regression, relationship between search breadth and depth and degree of innovativeness - moderation effect of exploration and exploitation orientation

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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01
Appendix 17: Statistical significance of partial effects of external search breadth by degree of ambidexterity
Level of partial effect of external search breadth on valuation performance at very high ambiguity.

- (1) Upper & lower confidence interval
- (2) Average partial effect
Appendix 18: Statistical significance of partial effects of external search depth by degree of ambidexterity
Level of partial effect of external search breadth on performance at very high ambiguity

External search breadth

(1) Upper & lower confidence interval
(2) Average partial effect
Appendix 19: Tobit regression, relationship between search breadth and depth, and incremental and radical innovation performance - sample specialized and ambidextrous strategies

Relationship between search breadth and depth and different degrees of innovativeness - sample specialized strategies

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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01
### Relationship between search breadth and depth and different degrees of innovativeness—sample ambidextrous strategies

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Two-tailed t-test applied. * p < 0.10, ** p < 0.05, *** p < 0.01
References


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33 In light of the recent developments regarding the publications of Ulrich Lichtenthaler, the publications cited in this thesis were checked before submission of this thesis. As of that time, the respective publications were not among the retracted publications. Upon new developments and further retractions the status of the respective citations in this thesis shall be examined again.


Management no. ERS-2004-005-ORG, Rotterdam School of Management, Rotterdam, Netherlands.


