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EXTERNAL SEARCH FOR EXPLORATION OF FUTURE DISCONTINUITIES AND TRENDS

Implications from the literature using co-citation and content analysis

Sara Heuschneider*, Cornelius Herstatt

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Hamburg University of Technology (TUHH)

Institute for Technology and Innovation Management

Schwarzenbergstr. 95
D-21073 Hamburg

Tel.: +49 40 42878 3777
Fax: +49 40 42878 2867

sara.heuschneider@tuhh.de
www.tuhh.de/tim
* Corresponding author

Abstract

To stay ahead of the competition, firms need to constantly adapt to the changing environment by identifying new opportunities and product innovations. The search for future discontinuities and trends using external knowledge sources enables firms to develop a foresight capability to proactively shape future direction and to improve innovation capacity. Recent open innovation literature discusses external search strategies and their impact on innovation performance. In order to investigate the implications of these findings for external search in the context of foresight, this paper aims to systematically analyze the current focus and intellectual structure of the external search field by means of co-citation and content analysis.

Findings indicate a strong focus of the research field on the external search for innovations, e.g. for new product ideas and problem solutions throughout the innovation process. However, it is so far poorly understood how firms can employ external search to detect future discontinuities and trends in the environment. To address this knowledge gap, dimensions of search strategies are derived from the current external search literature and are assessed with respect to their relevance for search in the context of foresight. In the course of the discussion, the breadth and depth of external search as well as the technological, geographical and relational distance of search are found to be relevant dimensions of external search strategies for identifying future developments. The identified dimensions can serve as a starting point to further investigate how firms can benefit from different external search strategies to identify discontinuities and trends in the environment. The paper closes with practical implications and suggestions for further research in this area.

Keywords: External search, corporate foresight, discontinuities, trends, innovation management, search strategies

1 Introduction

In today's dynamic environment competitive advantage is largely driven by a firm's ability to constantly adapt to change by identifying new market opportunities and product innovations. Paying attention to so-called weak signals that constitute early indicators of discontinuities and trends (Ansoff 1975) enables firms to identify potential future developments early on and to adjust their strategic direction accordingly (Whitehead 1967). To achieve this, firms need to develop a foresight capability to understand potential future states and to draw implications for their future direction (Horton 1999; Martin and Irvine 1989). Insights gained from foresight activities enhance a firm's innovation capability by exploring new business areas and creating new product ideas (Rohrbeck and Gemünden 2011). However, detecting early signs of future discontinuities and trends is challenging since they often originate outside a firm's area of expertise (Day and Schoemaker 2004; Harris and Zeisler 2002). Hence, foresight literature stresses the importance of utilizing external knowledge sources to broaden a firm's knowledge base and reduce the risk of 'blind spots' (Becker 2002; Daheim and Uerz 2008; Hoisl et al. 2015). According to the behavioral theory literature (Cyert and March 1963; Nelson and Winter 1982), firms conduct external search by spanning organizational boundaries to move beyond local search (Levitt and March 1988; Rosenkopf and Nerkar 2001). While the use of external knowledge has always been an important part of foresight (Becker 2002; Rohrbeck and Gemünden 2008), it has recently been reinforced by adopting insights from the open and user innovation literature (Daheim and Uerz 2008; Ehls et al. 2016; Miemis et al. 2012). Here, research on open innovation has analyzed different external search strategies and their impact on innovation performance (Katila and

Ahuja 2002; Laursen and Salter 2006). However, given the long-term orientation and uncertainty of foresight activities (Horton 1999), the search for future discontinuities and trends may require different search strategies as opposed to the search for innovations. In order to gain a better understanding of the implications of external search strategies in the context of foresight, we aim to analyze the current research field of external search behavior. For this, a co-citation and content analysis are applied to identify the intellectual structure of the field, the current research focus, and dimensions of search strategies that affect external search.

Findings reveal a certain fragmentation of the research field, which is dominated by two dominant streams related to external search and innovation as well as knowledge transfer and integration. Further, a strong focus on the external search for innovations, e.g. for new product ideas and problem solutions throughout the innovation process, is identified. Literature on external search for environmental discontinuities and trends is so far underrepresented in the research area. Based on the current external search literature, dimensions of search strategies are derived and assessed with respect to their relevance for search in the context of foresight. In the course of the discussion, the breadth and depth of external search as well as the technological, geographical and relational distance of search are found to be relevant dimensions of external search strategies for identifying future developments. The findings contribute to research and practice by providing initial guidance for relevant decisions on where and how to search for indicators of future trends. The identified dimensions can serve as a starting point to further investigate how firms can utilize external search strategies to identify future discontinuities and trends in the environment.

The remainder of this paper is structured as follows: In Section 2, the theoretical foundations on organizational search and corporate foresight are discussed and the research questions of this paper are derived. To address these questions, Section 3 outlines the applied research methodology and resulting dataset. Analysis results are presented in Section 4 and are discussed with respect to their implications on the search for weak signals in Section 5. Finally, in Section 6, the findings are summarized and implications for research and practice are proposed.

2 Theoretical background and research questions

2.1 Organizational search behavior

According to the behavioral theory of the firm (Cyert and March 1963; Nelson and Winter 1982), organizational behavior is goal directed, history dependent, and determined by routines (Levitt and March 1988). In order to improve performance or adapt to a changing environment, organizations need to search for alternatives that may deviate from their existing routines (Levitt and March 1988; Nelson and Winter 1982). In this context, organizational search is broadly understood as encompassing all activities "which are associated with the evaluation of current routines and which may lead to their modification, to more drastic change, and to their replacement" (Nelson and Winter 1982, p. 400). Search activities are characterized as being directed, controlled and proactive with the aim to identify and evaluate new knowledge (Li et al. 2013). Emphasizing the notion of adapting firm routines in response to acquired knowledge, organizational search is also conceived as a sub-process of organizational learning (Huber 1991; Levitt and March 1988).

While organizational search is either problem-driven or opportunity-oriented (Carter 1971), it is also associated with certain costs related to the effort of conducting search (Nickerson and Zenger 2004). In order to explore valuable knowledge, organizational decision makers therefore need to determine the optimal search

strategy that shapes the direction of search activities while maintaining efficient search processes (Nelson and Winter 1982; Nickerson and Zenger 2004). As part of the search strategy, decision makers need to define whether search activities are directed towards the firm's internal or external knowledge sources (Huber 1991). In the course of the evolvement of the open innovation paradigm (Chesbrough 2003), the notion of external search has received significant attention in the innovation literature. External search is directed towards a firm's problem solving activities that involve the creation and recombination of knowledge and expertise from a wide range of external sources such as customers, suppliers, competitors or universities (Katila and Ahuja 2002; Laursen and Salter 2006; Laursen and Salter 2014). The importance of external knowledge sources can be traced back to the literature on the resource-based view of the firm (Barney 1991; Peteraf 1993; Wernerfelt 1984). By utilizing external sources, firms are able to benefit from an increased knowledge variety that may be unrelated to the firm's current knowledge base (Bierly and Chakrabarti 1996; Lopez-Vega et al. 2006) and supports the exploration of new possibilities (March 1991). External search enables the firm to span organizational boundaries and thus, to move beyond local search to avoid competency traps and core rigidity (Leonard-Barton 1995; Levitt and March 1988; Rosenkopf and Nerkar 2001). However, literature has highlighted the importance of absorptive capacity as a firm's ability to recognize, assimilate and apply valuable external knowledge for firm purposes in order to fully exploit its benefits (Cohen and Levinthal 1990).

Recent literature discusses various dimensions of a firm's external search strategy such as the breadth and depth of external search (Katila and Ahuja 2002; Laursen and Salter 2006), which has also been referred to as the openness of a firm's search strategy (Cruz-González et al. 2015b; Laursen and Salter 2006). The impact of external search strategies on innovation and firm performance is controversially discussed. While an externally oriented search strategy is generally found to positively influence innovation output (e.g., Leiponen and Helfat 2010; Sofka and Grimpe 2010), findings also indicate that 'over-searching' may have a negative impact due to increased costs associated with the management of external sources and integration of external knowledge (Katila and Ahuja 2002; Laursen and Salter 2006).

2.2 Corporate foresight

In order to cope with a constantly changing environment, organizations need to identify discontinuities and trends before they emerge to proactively adjust their strategies (Whitehead 1967). In this context, the term foresight has been shaped as a firm's "ability to create and maintain a high-quality, coherent and functional forward view and to use the insights arising in organisationally useful ways" (Slaughter 1997, p. 13). Foresight therefore aims to develop an understanding of potential future states and to draw implications for an organization's current strategic decisions (Horton 1999; Martin and Irvine 1989). An important objective of foresight is to enable the firm to proactively shape future developments rather than to simply react to the changing environment (Godet and Roubelat 1996; Martin 1995). Originating from traditional forecasting, foresight emerged in research and practice as a separate field emphasizing a long-term future orientation with high degree of uncertainty (Cuhls 2003; Kuosa 2012; Martin and Irvine 1989). While a plethora of terms exist in literature describing different perspectives of foresight (see e.g., Rohrbeck and Gemünden 2008; Thom 2010), the term corporate foresight will be used in the following to emphasize the investigation of the future from a company perspective (Ruff 2006; Von der Gracht et al. 2010).

In order to identify potential future developments, organizations need to pay

attention to so-called weak signals that constitute early indicators of discontinuities and trends (Ansoff 1975). This implies that firms need to focus on both constantly adapting to incremental change originating from environmental trends as well as managing radical changes induced by external discontinuities (Liebl and Schwarz 2010; Rohrbeck and Gemünden 2009). In this context, foresight involves the systematic search for early signs of such discontinuities and trends in order to identify potential future states (Farrington et al. 2012; Harris and Zeisler 2002; Holmes and Smart 2009). With respect to organizational search theory, foresight activities constitute a form of forward-looking search where decisions about alternatives are based on the decision maker's understanding of future developments (Chen 2008; Gavetti and Levinthal 2000; Rohrbeck et al. 2015). The identification of potential future developments provides the basis for further analysis and interpretation in the course of the foresight process. Hence, the search for discontinuities and trends is located in the initial phase of foresight, which is associated with exploration and broad collection of potentially relevant knowledge (Horton 1999; Popper 2008). In the subsequent phases, the retrieved knowledge is used to analyze potential future states and to derive implications for the firm (Voros 2003).

Uncovering early signs of discontinuities and trends is a challenging task since they often originate outside a firm's domain and require organizations to look beyond their area of expertise (Day and Schoemaker 2004; Harris and Zeisler 2002; Kuosa 2012). As a consequence, solely relying on internal sources poses the risk of 'blind spots' for the firm (Day and Schoemaker 2004). Foresight literature therefore stresses the importance to utilize external actors in order to broaden the knowledge base (Becker 2002; Hoisl et al. 2015). Inspired by the body of literature of open and user innovation (Chesbrough 2003; West and Bogers 2014; Von Hippel 1986), a recent claim to advance foresight practices towards a more open understanding has emerged in the literature (Daheim and Uerz 2008; Miemis et al. 2012). Coined under the term 'open foresight' the aim is to systematically utilize distributed information sources for foresight activities by drawing from insights and methods of the open innovation literature (Ehls et al. 2016; Gattringer and Strehl 2014).

Insights gained from foresight activities can be of value for different functional units such as strategic management, innovation management, and corporate development (Rohrbeck and Gemünden 2011). Due to its cross-functional and long-term orientation, measuring the impact of foresight activities is difficult (Horton 1999; Rohrbeck 2012). Nevertheless, several studies have sought to identify potential value contributions of foresight with respect to reducing uncertainty and identifying changes in the environment (Rohrbeck and Schwarz 2013; Thom 2010), innovation performance (Heger and Boman 2015; Paliokaite and Pacesa 2015), and general firm performance (Amsteus 2011).

2.3 Research questions

The use of external knowledge to search for future developments has always been an important part of foresight practices (Becker 2002; Rohrbeck and Gemünden 2008) and has recently been reinforced by adopting insights from the open innovation literature (Daheim and Uerz 2008; Miemis et al. 2012). However, so far it is poorly understood how firms need to shape their external search strategies in order to detect potential discontinuities and trends. By linking foresight research with the broader theory on organizational behavior and external search this paper aims to gain a better understanding of potential implications of external search strategies for corporate foresight activities. The focus is hereby on uncovering the intellectual pillars and relevant schools of thought that constitute the theoretical foundation of the research field. Additionally, by systematically analyzing the existing

literature on external search behavior, the paper aims to determine the current research focus as well as dimensions of external search strategies that may be of relevance for search in the context of foresight. Hence, the following research questions will guide the further analysis:

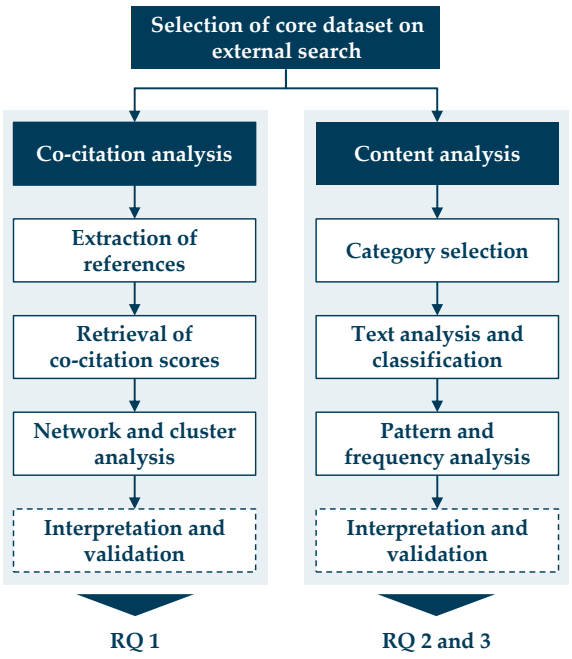
RQ 1: What is the intellectual structure of the research field of external search behavior?
RQ 2: What is the current research focus of existing literature on external search behavior?
RQ 3: Which dimensions of search strategies can be identified from existing research that impact external search behavior?

By answering these questions, this paper attempts to accomplish a holistic understanding of the research on external search behavior in order to draw implications for further research in the context of corporate foresight.

3 Methodology

For answering the research questions, this paper follows a structured approach as illustrated in Figure 1.

Figure 1: Research approach (own illustration)



First, relevant publications in the field of external search are systematically identified that serve as a basis for further detailed analysis. In order to answer RQ 1, a quantitative approach is applied by conducting a co-citation analysis based on the bibliographies of the core dataset to reveal the intellectual structure and theoretical foundation of the research field. Further, RQ 2 and RQ 3 are addressed by a systematic content analysis of the publications in the core dataset.

3.1 Selection of core dataset on external search

In order to identify the set of relevant publications in the field of external search for further analysis, a web search was conducted in February 2016. Here, the decision was taken to search in multiple databases to reduce the risk of missing relevant publications (Raasch et al. 2013). Following this strategy, the academic databases ISI Web of Science (Core Collection), EBSCO Business Source Premier, and ProQuest (Business) were searched for relevant publications. To limit the scope and increase the validity of search results, the search was conducted based on selected search terms. Since literature highlights the importance of carefully defining search terms that accurately represent the targeted research field (Zupic and Cater 2014), a keyword analysis on an initial set of relevant publications was initiated prior to the actual database search. For this, the database ISI Web of Science was searched with the theory-deduced search phrase "external search" OR "open search" and the restriction on an organizational context[1]. After reviewing the search results with respect to relevance for the examined field, a set of 13 publications was identified and analyzed for relevant further keywords in the field. Based on the results of the keyword analysis, the final search phrase was defined as a combination of "search" OR "information seeking" OR "knowledge seeking"

[1] Exact search phrase: ("external search" OR "open search") AND ("organi?ation" OR "firm" OR "company" OR "corporate")

AND "open" OR "external" OR "distant" OR "outside" OR "broadcast"[2]. The search term is defined intentionally broad since literature on external search behavior is diverse and no commonly agreed terminology has been established so far. This approach follows comparable reviews such as within the field of open innovation (Dahlander and Gann 2010; Randhawa et al. 2016). The search included the publication title, keywords and abstracts, and yielded an initial result of 23,880 publications. Some further filter criteria were applied in order to increase the relevance of the search results: (1) the language is limited to English, (2) the publication type is restricted to peer-reviewed academic articles, conference articles, book chapters and books, and (3) the research field is limited to business- and management-related publications. After filtering, 1,158 publications remained in the search results. Since multiple databases were searched, results need to be checked for redundancy, which excluded further 162 publications (redundancy rate of 14%[3]) resulting in a dataset of 996 publications.

While defining the search phase very broad ensures a comprehensive view on potentially relevant publications, a detailed review of the search results is inevitable since irrelevant publications can introduce outliers and decrease the validity of the results (Zupic and Cater 2014). Therefore, an iterative review of the abstracts and texts of all publications was conducted in order to assess the relevance for the field of external search. In the course of the review, publications were excluded that (1) do not explicitly investigate external knowledge search (e.g., crowdsourcing and organizational learning without reference to search behavior), (2) focus on internal knowledge sources (e.g., research on knowledge search within organizations), lack organizational context (e.g., job search, consumer search behavior), and (4) do not have a research focus (e.g., commentary essays). In order to reduce bias, exact decision criteria for exclusion of publications were defined beforehand to ensure a transparent and replicable outcome (Zupic and Cater 2014). As a result, the final dataset contains 108 publications that are used for the following analysis.

3.2 Co-citation analysis

For answering RQ 1, a co-citation analysis will be applied. Bibliographic citations in scientific papers have been used by researchers to empirically study the structure and development of a research field (Gmür 2003; Small 1973) and thus, to utilize a quantitative technique (Pritchard 1969). A citation is generally understood as a measure of the significance of the reference and as an indicator for scientific communication (Garfield 1979; Small 1978). Besides direct citation and bibliographic coupling methods, co-citation has been applied widely as a measure of subject similarity (Small 1973; Verbeek et al. 2002). A co-citation exists if two references or authors are cited together (Gmür 2003). The strength of a co-citation is then determined by "the frequency with which two items of earlier literature are cited together by the later literature" (Small 1973, p. 265). This approach is based on the assumptions that co-citation indicates similarity of content (Di Guardo and Harrigan 2012), all citations are of the same significance, and citation reflects the merit of the publication with respect to quality, significance or impact (Verbeek et al. 2002). Thus, the strength of co-citation can be interpreted as the proximity between publications so that co-citation patterns can be applied to uncover relationships and structures in a research field (Gmür 2003; Small 1973).

Before conducting the co-citation analysis, the co-citation object needs to be defined, which leads to either an author- or document-based

[2] Exact search phrase: ("search" OR "information seeking" OR "knowledge seeking") AND ("open" OR "external" OR "distant" OR "outside" OR "broadcast")

[3] Number of duplicate filtered publications divided by the total number of filtered publications

approach (Gmür 2003). Since the aim of this paper is to reveal the intellectual structure and central constructs of the research field of external search behavior, a document co-citation approach is chosen. The focus on documents as the unit of analysis is based on the premise that these constitute the most valid and reliable indicator for the underlying structure of a research field (Chen et al. 2010; Small 1973).

Extraction of references

The bibliographic data of all 108 publications in the core dataset were manually extracted and transferred into a database. The retrieved data includes authors, title, publication year, and journal information for each citation. Further, citations were checked for errors and inconsistencies such as spelling mistakes and wrong publication years. Standardization also includes to unify multiple editions of the same book and to merge working papers with later journal publications of the same title. The correction and standardization of the citations is essential since the quality of the raw data significantly influences co-citation results (Persson 1994). As a last step, non-science publications such as web articles and governmental surveys were excluded from the list, as these do not provide any relevant information with respect to the research question. The final dataset consists of 7,832 citations that map to a total of 4,448 unique citations.

As recommended by the literature, publications used for co-citation analysis should be matched against a predefined minimum citation threshold in order to ensure a manageable size of the dataset with publications that have a certain influence in the research area (Small and Greenlee 1980; Zupic and Cater 2014). While there exists no commonly agreed recommendation on the level of citation frequency thresholds in the literature (Small 1977; Zupic and Cater 2014), only publications that have been cited at least more than two times are included for the following analysis. The comparatively low threshold is chosen to reduce the bias of discriminating newer publications in the dataset and accomplish the goal of gaining a wide, inclusive view on the research field (Zupic and Cater 2014). By applying the selected threshold, the final list contains 513 unique citations.

Retrieval of co-citation scores

Based on the list of unique citations, the co-citation frequency for each pair of publications was obtained resulting in a 513x513 symmetrical matrix of absolute co-citation counts in which the diagonal remains undefined.

As a next step, the CoCit-Score was calculated for each pair in the matrix. The score is chosen since it shows a higher degree of robustness than the absolute co-citation count and has also demonstrated to be superior to other measures (Gmür 2003). Introduced by Gmür (2003), the score includes the minimum and mean count of the individual citations for each pair of publications, and thus, reduces the influence of the citation relation of these two references by giving weight to both symmetrical and asymmetrical co-citation pairings. The CoCit-Score results in a value between 0 and 1 and is calculated as follows:

$$\mathrm{CoCit}_{AB} = \frac{(\text{co-citation}_{AB})^2}{\min(\text{citation}_A;\text{citation}_B) \times \text{mean}(\text{citation}_A;\text{citation}_B)}$$

The retrieved weighted co-citation matrix was then prepared for the import to a network analysis tool. For this, the Organizational Risk Analyzer (ORA) was chosen as a network analysis tool that enables visual and statistical network analysis and assessment (Carley 2014).

Network and cluster analysis

For analyzing the structure of the research field, network analysis methods are applied. In the co-citation network, the nodes represent individual publications while the links between nodes indicate a co-citation relationship based on the CoCit-Score (Zupic and Cater 2014). Proximity between the nodes is visualized based on the value of the link. As an initial step, the entire

network is analyzed to reveal the most central publications in the network. Here, centrality measures, namely degree centrality, closeness centrality, and betweenness centrality, are used by the literature to evaluate the local and global role of nodes in a network (Freeman 1978). Degree centrality reflects a node's position in the network based on its number of immediate ties (Wasserman and Faust 1994; Wellman et al. 2006). In contrast, closeness centrality focuses on the total distance of a node from all other network nodes where closeness is reflected by a high number of short links to other nodes (Freeman 1978; Otte and Rousseau 2002). Finally, betweenness centrality indicates the frequency with which a node is found to be on the shortest link between any pair of nodes in the network indicating a brokering function (Freeman 1978; Wellman et al. 2006). Additionally, the entire network is analyzed with respect to its density, which indicates the general connectiveness of the network through the extent by which its nodes are directly connected with one another (Otte and Rousseau 2002; Wellman et al. 2006).

In order to identify subfields for answering RQ 1, a cluster analysis of the co-citation network is performed. To identify relevant clusters, the network is visualized and analyzed by comparing the structure at different co-citation thresholds between 0.4 and 0.7. Selecting an appropriate threshold is necessary to unambiguously define a cluster (Small 1980) and requires finding a balance between size of clusters and strength of connectivity between nodes in a cluster. At a threshold of ≥0.45 and a component size of >3 a total of 14 clusters are identified that are used for further analysis. Network components of three or less nodes are excluded from further analysis due to the small cluster size. For each cluster, publications were then retrieved and reviewed in order to identify the common subject. In the course of the review, methodology-related papers were identified and excluded from the analysis since they tend to introduce bias by tying together portions of data (Small and Sweeney 1985).

To ensure a high degree of reliability, the process of reference extraction, cluster identification and interpretation follows a structured, transparent and well-documented procedure with clear decision rules. In terms of validity of the results, co-citation literature has pointed towards potential limitation with respect to negative citations, self-citations, and methodological papers (Garfield 1979). While the latter has been addressed by excluding methodology-related papers, as previously outlined, Garfield (1979) argues for the non-relevance of the first two aspects due to their rather theoretical impact. Consequently, co-citation analysis is found to be a valid indicator for the structure of a research field (Boyack and Klavans 2010; Garfield 1979; Small 1973).

3.3 Content analysis

Based on the initial core dataset on external search, a comprehensive literature review by means of content analysis is conducted. While qualitative reviews have been criticized for their limitations (e.g., Cook and Leviton 1980), it is a commonly employed method to create a firm understanding of the current literature in a field as a foundation for further research (Webster and Watson 2002). However, since content analysis involves the systematic and rule-governed analysis of text-based material (Mayring 2008), it reduces subjective bias by aiming for objectivity and replicability (Krippendorff 1980). Amongst others, content analysis has been applied in the literature to analyze published material (e.g., Gold et al. 2010; Jauch et al. 1980). Due to its systematic approach, it is therefore a useful method to create valid and reliable findings in the course of literature reviews (Seuring and Gold 2012).

Category selection

Content analysis involves a systematic classification process to identify patterns or underlying themes in the literature (Guthrie et

al. 2004; Hsieh and Shannon 2005) and is based on the assumption that category frequency relates to the importance of the underlying subject (Krippendorff 1980). With respect to the research questions of this paper, categories for classifying the reviewed publications were defined prior to the start of the analysis and refined during the course of the review employing an iterative process of category building, testing and revisiting (Eisenhardt 1989; Mayring 2008). An overview of the categories with the respective coding scheme is given in the appendix (see Table 5). As recommended by Krippendorf (1980), the selection of categories is largely based on existing conceptualizations from comparable literature. Addressing RQ 2, the dataset is analyzed according to the research method, research area, level of analysis, and empirical sample. For coding of the research method, the taxonomy developed by Wacker (1998) is used, which distinguishes broadly between analytical and empirical methods. For the research area, the classification approach by Lyles (1990) serves as a basis and is further adjusted to the specific focus of publications in the dataset. The level of analysis differentiates between firm-, project-, and individual-level, as for example used by Li et al. (2008). Finally, the empirical sample is analyzed according to sample size and industry as classified by the NAICS coding scheme (NAICS 2016). With respect to RQ 3, publications are analyzed according to the focus of the external search and examined search dimensions. Since there exists no suitable classification in the literature, inductive category development (Mayring 2008) was applied to derive the coding for these two categories from the analyzed data.

Evaluation and descriptive analysis

All publications in the dataset are analyzed according to the outlined categories. Additionally, a descriptive analysis of publication years and distribution of journals is conducted. Further patterns are identified by frequency analysis of category occurrence for all dimensions. The entire coding and analysis process was documented in order to ensure transparency and replicability of the research design. Further, Krippendorff (1980) highlights the importance of reliability and validity of results from content analysis. As the categorization scheme is clearly defined and derived from well-grounded literature, reliability of the coding is enhanced reducing the need for multiple coders (Guthrie et al. 2004). With respect to external validity, de-contextualization and abstraction of results of the content analysis allow for a certain generalization of the findings (Seuring and Gold 2012).

4 Results

4.1 Intellectual structure of the research field on external search

The theoretical foundations and structure of the research field on external search can be derived from the co-citation network. The entire network has a total size of 513 nodes and more than 74,000 links with a mean co-citation strength of 0.079. By applying a link threshold of ≥0.45 and component threshold of >3 the network is restricted to a size of 89 publications distributed over 14 clusters. It includes 310 links with a mean co-citation strength of 0.652. The network density of the reduced network is 0.035 indicating a low connectivity due to the chosen thresholds to identify clusters. However, the original network without any thresholds shows a network density of 0.283 representing a sparse network. While low network density may also be influenced by the overall network size (Raasch et al. 2013), it serves as an indicator for a general fragmentation of the intellectual pillars of the research field.

Centrality measures

The analysis of the centrality of individual publications is based on the entire network with no thresholds applied in order to obtain insights into the overall structure of the network. Table 1

summarizes the top 10 publications for the measures of degree centrality, closeness centrality, and betweenness centrality. Since the number of direct links of a node defines degree centrality, it uncovers publications that are highly connected within the network and thus, can be interpreted as important concepts in the field of external search. As the mean degree centrality value for the entire network is 0.023, the highest ranked publications all show a considerably higher degree centrality. Thus, the most central positions in the network in terms of direct links comprise the concepts of absorptive capacity (Cohen and Levinthal 1990), boundary-spanning search (Katila and Ahuja 2002; Laursen and Salter 2006; Leiponen and Helfat 2010; Rosenkopf and Nerkar 2001), open and user innovation (Chesbrough 2003; Von Hippel 1988), and theory on organizational search and learning (Nelson and Winter 1982; March 1991; Kogut and Zander 1992). In contrast, the closeness centrality reflects physical proximity in the network and shows a mean closeness centrality value of 0.084. Similar to the degree centrality results, publications related to the theory on organizational search and learning (Cyert and March 1963; Huber 1991; Nelson and Winter 1982; March 1991), user innovation (Von Hippel 1988), absorptive capacity (Cohen and Levinthal 1989), and boundary-spanning search (Katila 2002; Leiponen and Helfat 2010) are highly ranked. In addition, two publications related to resource complementarities in innovation (Cassiman and Veugelers 2006), and innovation intermediaries (Howells 2006) appear as being central in terms of proximity to other nodes in the network. However, it should be noted that some of the top 10 publications are not included in any of the 14 clusters described in the following section since the strength of ties is not reflected in this measure. Finally, the betweenness centrality shows publications that link parts of the network and thus act as a broker to connect different concepts. Again, the top 10 ranked publications show a significant higher value as the mean betweenness centrality value of the network (0.003).

Table 1: Overview of most central publications in the network (own analysis)

	Total degree centrality		**Closeness centrality**		**Betweenness centrality**	
Rank	**Publication**	**Value**[4]	**Publication**	**Value**[4]	**Publication**	**Value**[4]
1	Cohen and Levinthal 1990	0.100	Huber 1991	0.118	March 1991	0.118
2	Laursen and Salter 2006	0.087	Leiponen and Helfat 2010	0.116	Nelson and Winter 1982	0.113
3	Rosenkopf and Nerkar 2001	0.086	Von Hippel 1988	0.114	Laursen and Salter 2006	0.103
4	Chesbrough 2003	0.080	Cassiman and Veugelers 2006	0.114	Von Hippel 1988	0.097
5	Katila and Ahuja 2002	0.076	Cohen and Levinthal 1989	0.113	Katila and Ahuja 2002	0.095
6	Nelson and Winter 1982	0.070	Katila 2002	0.113	Leiponen and Helfat 2010	0.095
7	March 1991	0.069	Nelson and Winter 1982	0.113	Huber 1991	0.094
8	Leiponen and Helfat 2010	0.063	Howells 2006	0.112	Chesbrough 2003	0.088
9	Von Hippel 1988	0.061	Cyert and March 1963	0.112	Cyert and March 1963	0.077
10	Kogut and Zander 1992	0.058	March 1991	0.112	Rosenkopf and Nerkar 2001	0.068

[4] Scaled value as normalized measure

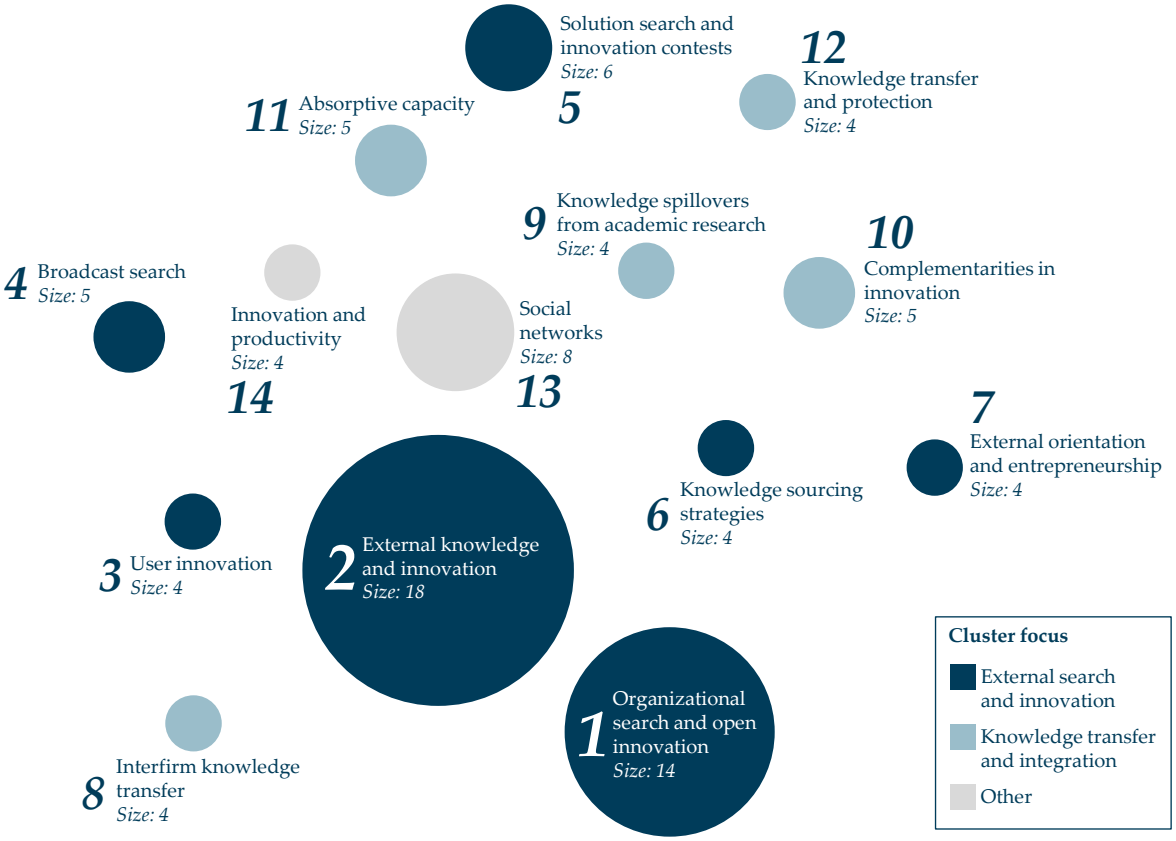
An important brokering role can be attributed to publications related to the theory on organizational search and learning (Cyert and March 1963; Huber 1991; Nelson and Winter 1982; March 1991), boundary-spanning search (Katila and Ahuja 2002; Laursen and Salter 2006; Leiponen and Helfat 2010; Rosenkopf and Nerkar 2001), and open and user innovation (Chesbrough 2003; Von Hippel 1988). Again, two publications, namely Cyert and March (1963) and Huber (1991), appear here that are not included in the cluster analysis due to their low link strength.

Cluster distribution

The identified 14 clusters are visualized in Figure 2. An overview of the publications per cluster can be found in the appendix (see Table 8). While the size of the clusters represents the number of publications in each cluster, the physical proximity between the clusters can be interpreted as the closeness of the represented theoretical concepts. Analysis of the publications in the cluster reveals three groups, namely clusters focusing on external search and innovation, knowledge transfer and integration, and others with a general innovation- or sociology-related focus. Being part of the first group, two clusters on organizational search and open innovation, and on external knowledge and innovation dominate the picture.

Table 2 shows the journal distribution of the publications in the cluster. While a significant number of publications are published in the Research Policy and Strategic Management Journal, the overall distribution is quite fragmented with 79 publications being published in 26 different journals.

Figure 2: Overview of clusters at a threshold of 0.45 link strength (own analysis)



This may imply that the intellectual pillars of the research field are so far rather dispersed across various research areas. In the following sections, the clusters are outlined in detail with respect to their relevance for the external search field.

Table 2: Journal distribution of publications in clusters (own analysis)

Journal	Publications No.	%
Research Policy	12	13.48
Strategic Management Journal	11	12.36
Technovation	9	10.11
Organization Science	7	7.87
Management Science	5	5.62
Academy of Management Review	4	4.49
Administrative Science Quarterly	4	4.49
American Economic Review	3	3.37
Academy of Management Journal	3	3.37
R&D Management	2	2.25
American Journal of Sociology	2	2.25
Technological Forecasting and Social Change	2	2.25
Journal of Marketing	2	2.25
Other (journals)[5]	13	11.24
Other (non-journals)[6]	10	14.61
Total	**89**	

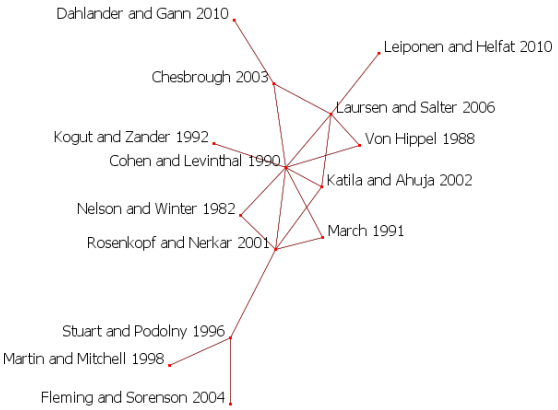
Organizational search and open innovation (cluster 1)

The first cluster consists of 14 publications ranging from 1982 to 2010 that combine the theoretical foundations of organizational search and open innovation (see Figure 3). On the one hand, the cluster includes the publications of Chesbrough (2003), Dahlander and Gann (2010), and Von Hippel (1988) as representatives of the open innovation concept emphasizing the opening of firm boundaries for external knowledge. On the other hand, it comprises the traditional works of March (1991) as well as Nelson and Winter (1982) on organizational search and learning. At the intersection of these two streams, a range of prominent publications can be found that focus on the use of external knowledge sources for organizational search. Here, the openness of a firm's external search strategy is discussed in terms of breadth and depth of external search (Katila and Ahuja 2002; Laursen and Salter 2006; Leiponen and Helfat 2010). Additionally, the ability to assimilate and apply external knowledge for organizational purposes is highlighted by the papers of Cohen and Levinthal (1990) as well as Kogut and Zander (1992), which introduce the concepts of absorptive capacity and combinative capabilities. Finally, Rosenkopf and Nerkar (2001) analyze the notion of boundary-spanning search with a focus on internal versus external search and local versus distant search. Bridged by this work, other authors discuss aspects of local search and their impact on innovation activities (Fleming and Sorenson 2004; Martin and Mitchell 1998; Stuart and Podolny 1996). The discussed relationships can also be derived from the cluster structure: authors focusing on the concepts of absorptive capacity and external search serve as a bridging element, or broker (De Nooy et al. 2005), between the more fundamental works on open innovation and organizational search. With respect to centrality measures, the work of Cohen and Levinthal (1990) shows the highest betweenness centrality value indicating an important brokering role in this network. Overall, the cluster can be understood as providing the theoretical foundations of external search in the innovation context by connecting fundamental research on organizational search and learning with the more recent evolvement of open innovation. Publications at the intersection of these two streams provide insights into relevant determinants and dimensions of external search that affect overall search effectiveness.

[5] Journals with only one publication each

[6] Non-journals, e.g. books, book sections, with only one publication each

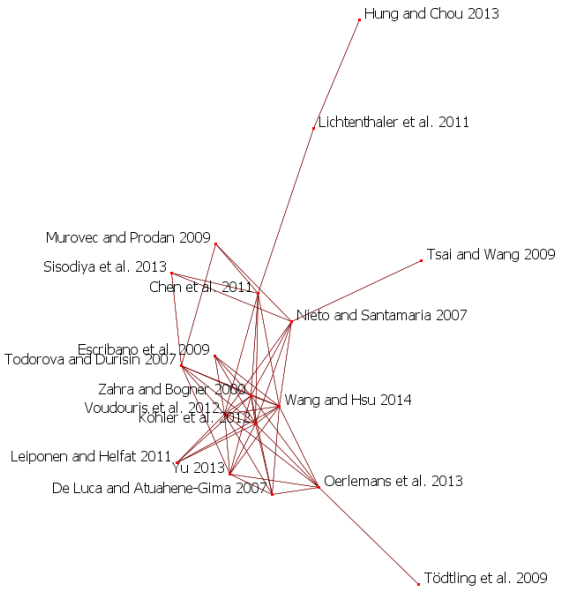
Figure 3: Cluster 1 – Organizational search and open innovation



External knowledge and innovation (cluster 2)

The largest cluster in the network is a comparatively young cluster containing 18 publications from the years 2000 to 2014 (see Figure 4). Its focus lies on utilizing external knowledge in an innovation context. The most central nodes in this network with respect to total degree centrality are the publications of Köhler et al. (2012), Voudouris et al. (2012), Wang and Hsu (2014), and Zahra and Bogner (2000). Köhler et al. (2012) analyze the impact of different external knowledge sources on the innovation performance of firms emphasizing the need to assess the suitability of external sources for a firm's search strategy. With a focus on relationship learning, Wang and Hsu (2014) discuss external sources for innovation by focusing on the mediating role of power asymmetry in a relationship. Similarly, Zahra and Bogner (2000) analyze a firm's technology strategy and, among other factors, the use of external technology sources with respect to their impact on firm performance. Finally, Voudouris et al. (2012) emphasize the role of networking as a firm's external linkages to accumulate internal technological capabilities. Other authors in this network focus on the diversity of external sources and its relationship with innovation performance (Oerlemans et al. 2013; Yu 2013). Additional papers evaluate how specific types of external knowledge such as scientific and business partner knowledge support different kinds of innovation (Nieto and Santamaria 2005; Tödtling et al. 2009). A broader view is taken by Chen et al. (2011), as they study the impact of the scope, depth and orientation of a firm's external search strategy on innovation outcome. Analogously, De Luca and Atuahene-Gima (2007) evaluate how breadth, depth, tacitness and specificity of market knowledge as an external source affect product innovation while taking into account different knowledge integration mechanisms. Further authors in this cluster also discuss the notion of external knowledge integration by focusing on different aspects of absorptive capacity depending on the type of external knowledge (Murovec and Prodan 2009; Todorova and Durisin 2007). In the context of external search behavior, this cluster provides fundamental insights into how firms may exploit different types of external knowledge sources to support innovation activities.

Figure 4: Cluster 2 – External knowledge and innovation

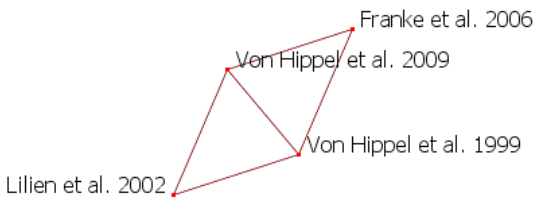


User innovation (cluster 3)

Close to the preceding cluster lies the third cluster with four publications from the years 1999 to 2009 (see Figure 5). While cluster 2 focuses on external knowledge sources in general, this cluster consists of publications

specifically discussing users as external sources for innovation. The cluster consists of two complete triads, or cliques (De Nooy et al. 2005), and is dominated by publications of and with Von Hippel as the originator of the user innovation concept. In Von Hippel et al. (2009) a search strategy is introduced to efficiently identify lead users within a given search space. Moreover, experience with lead users for idea generation in a company setting is reported (Von Hippel et al. 1999; Lilien et al. 2002). Finally, Franke et al. (2006) analyze the relationship between lead user characteristics and commercial innovation success. As lead users can provide insights on future trends and developments in the market prior to other users (Franke et al. 2006), they constitute a valuable knowledge source for a firm's external search activities to create new product ideas and identify future needs early on.

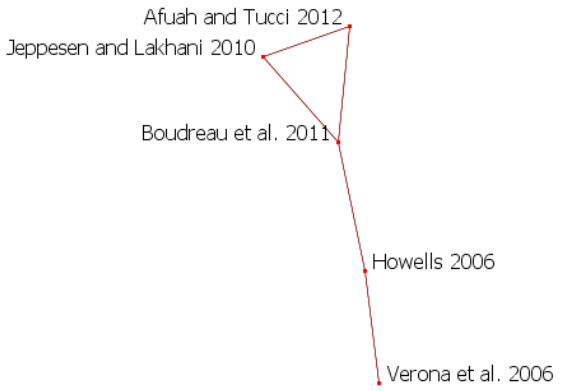
Figure 5: Cluster 3 – User innovation



Broadcast search (cluster 4)

This cluster encompasses five relatively young publications from the years 2006 to 2012 (see Figure 6). It focuses on the concept of crowdsourcing, or broadcast search, which is targeted at utilizing a broad mass of external actors for problem solving (Boudreau et al. 2011; Jeppesen and Lakhani 2010). As such, it is seen to enable distant search while reducing the costs usually associated with this type of search (Afuah and Tucci 2012). Three of the authors in this cluster build a complete triad indicating a close proximity between the concepts (De Nooy et al. 2005). They analyze the suitability of broadcast search from various perspectives. Afuah and Tucci (2012) discuss the type of the problem, the characteristics of the crowd, the required problem solving knowledge, and evaluation-related aspects as important factors when considering broadcast search. Boudreau et al. (2011) focus on innovation contests as a specific type of crowdsourcing and pay especially attention to the number of potential solvers and the problem uncertainty. Finally, Jeppesen and Lakhani (2010) show that distance in terms of expertise and social marginality has a positive impact on creating winning solutions in an innovation contest. In practice, broadcast search is often supported by intermediaries or knowledge brokers, which enable firms to increase their reach to external knowledge sources (Howells 2006; Verona et al. 2006). Bridged by the work of Boudreau et al. (2011), as indicated by a high betweenness centrality value, the concept of innovation intermediaries is attached to this cluster. While Howells (2006) analyze innovation intermediaries from a general theoretical view, Verona et al. (2006) explicitly discuss the role of virtual knowledge brokers who leverage the internet to enhance interactions between firms and customers.

Figure 6: Cluster 4 – Broadcast search



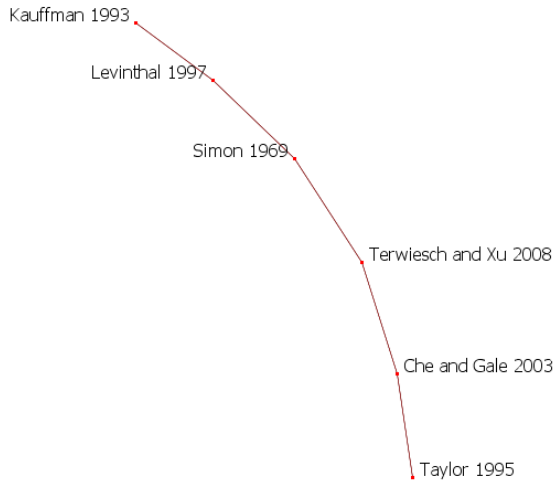
Most relevant for external search, the cluster focuses on the mechanisms and conditions when searching very broadly including a mass of potentially unknown external actors. While it is shown that this type of external search can provide valuable insights by utilizing diverse and distant knowledge, determinants such as

the type of the problem and characteristics of the potential solvers need to be taken into account when defining the external search strategy.

Solution search and innovation contests (cluster 5)

Cluster 5 encompasses six publications spanning the years of 1969 and 2008 (see Figure 7). The cluster is structured as a line network where each node is connected to exactly one other node (De Nooy et al. 2005). Unlike the majority of the other clusters, this cluster is more associated to a chain of concepts rather than to publications with the same research focus. Being located at one end of the line network, the work of Kauffman (1993) on adaptation in rugged fitness landscapes builds the basis for the concept of adaptive search for local and global optima in a solution space. As specified by Kauffman's NK model, the search landscape is defined by the number of attributes (N) and the number of interactions (K). With a direct connection to this concept, Levinthal (1997) introduces this model to management literature stating that organizational form results from a process of local search and adaptation. He finds that for tightly coupled organizations explorative search and adaptation is much more difficult than for loosely coupled ones. In the context of organizational problem solving, Simon (1969) discusses adaptive search as defined by the complexity of the solution landscape that is searched for a high-value solution. For difficult and novel problems, the landscape is more complex requiring a significant amount of trial-and-error search. Based on the notion of high-value solution search in a given knowledge space, the remaining publications in the cluster focus on innovation contests as a form of multi-agent problem solving. While Terwiesch and Xu (2008) analyze innovation contests with respect to the type of problem and optimal contest design, Che and Gale (2003) investigate contest design including the set of participants and winning prizes. Finally, Taylor (1995) develops a model of optimal contest design balancing the size of the prize, number of participants, and amount of entry fee. All three publications have in common that innovation is viewed as a problem solving process where firms search for high value solutions in an unknown solution landscape. The design of the contest thus defines the search strategy that is employed to navigate through this landscape from local to global optima. Since the actual search is performed by external contest participants, this cluster provides insights into solution search determinants for the external search literature.

Figure 7: Cluster 5 – Solution search and innovation contests

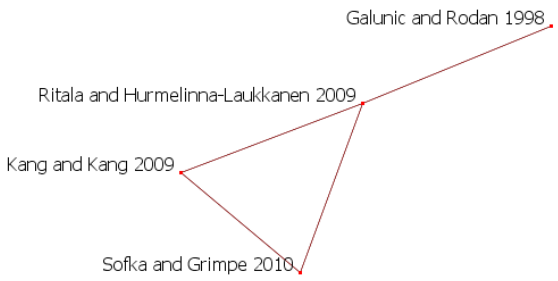


Knowledge sourcing strategies (cluster 6)

This cluster focuses on different knowledge sourcing strategies and includes four publications from the years 1998 to 2010 (see Figure 8). The structure of the cluster reveals a complete triad consisting of three of the four publications. Being part of this triad, Kang and Kang (2009) examine the effects of different external knowledge sourcing methods on innovation performance. Focusing on informal networks, R&D collaborations, and technology acquisition, they find that especially knowledge transfer from informal networks and R&D collaborations is positively related to innovation performance. Further, Sofka and Grimpe (2010) discuss the notion of specialized search strategies emphasizing the need to balance diversity of knowledge inflows and efficiency of

knowledge access. They distinguish science-, market- and supply-driven search strategies and find that particularly science- and supply-driven search enables innovation success while market-driven search is especially important when interacted with a firm's R&D investments. With a more narrow focus, Ritala and Hurmelinna-Laukkanen (2009) develop propositions on the effects of innovation-related coopetition in comparison to cooperation. They emphasize the value creation potential due to the common knowledge base of competitors about markets and technologies. Associated to the above outlined triad is the work of Galunic and Rodan (1998) on resource recombinations and their effect on innovation. While the authors examine the characteristics of knowledge and its social organization, the discussed notion of knowledge dispersion is especially relevant for this cluster. It is stated that widely dispersed knowledge may hinder innovative resource recombinations due to associated costs of exchange and low detection probability. Overall, the cluster shows the importance of carefully selecting relevant external knowledge sources with respect to the search focus, associated costs, and required knowledge.

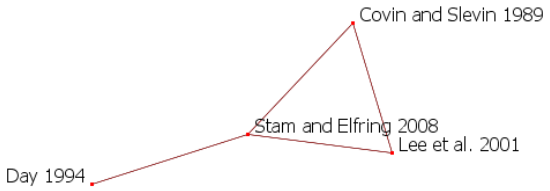
Figure 8: Cluster 6 – Knowledge sourcing strategies



External orientation and entrepreneurship (cluster 7)

Cluster 7 includes four publications from the years 1989 to 2008 and focuses on the topic of external orientation and entrepreneurship (see Figure 9). Based on the structure of the cluster, a complete triad can be identified indicating a strong interrelationship between the underlying concepts. From a general perspective, Covin and Slevin (1989) investigate the characteristics of small firms in hostile environments and show that an entrepreneurial orientation with high innovativeness, proactiveness and risk-taking is positively related to firm performance. Emphasizing an external orientation, Lee et al. (2001) study the role of external networks for new venture performance. Likewise, Stam and Elfring (2008) analyze the relationship between entrepreneurial orientation and performance dependent on the configuration of the intra- and extra-industry network ties. Connected to this triad and brokered by Stam and Elfring (2008) is the work of Day (1994) who discusses the general importance of an external orientation in terms of market sensing, customer linking and technology monitoring capabilities for market-driven organizations.

Figure 9: Cluster 7 – External orientation and entrepreneurship



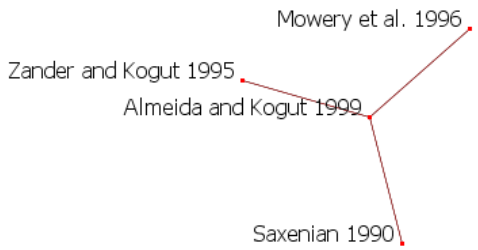
Although results are mixed, the publications in this cluster generally show the importance of fit between utilized external sources and required knowledge in an entrepreneurial setting. It can thus be assumed that the firm context and the associated firm-specific knowledge need is important for shaping a firm's external search strategy.

Interfirm knowledge transfer (cluster 8)

Cluster 8 comprises four publications dating from 1990 to 1999 (see Figure 10). It is a star network (De Nooy et al. 2005) with Almeida and Kogut (1999) being the central node that connects the other three publications. Their work focuses on knowledge transfer in regional networks by emphasizing the role of spatial localization of knowledge and investigating

how knowledge is transferred with focus on mobility paths of people. Similarly, Saxenian (1990) highlights the importance of relationships in regional networks by analyzing the resurgence of the Silicon Valley in the 1980s. From the perspective of strategic alliances, Mowery et al. (1996) examine effects of interfirm knowledge transfer on the technological capabilities of the partnering firms. In contrast, Zander and Kogut (1995) especially pay attention to the unwanted transfer of knowledge in the context of competitive imitation and evaluate different knowledge characteristics as determinants of the speed of internal and external knowledge transfer.

Figure 10: Cluster 8 – Interfirm knowledge transfer

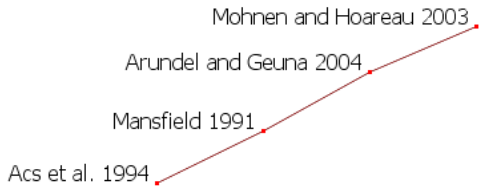


Overall, the publications in this cluster analyze the determinants of interfirm knowledge transfer from different perspectives. The cluster therefore builds the foundation for understanding how knowledge identified through external search activities is transferred between actors with a specific focus on firms as knowledge exchanging units.

Knowledge spillovers from academic research (cluster 9)

The line network of cluster 9 includes four publications from 1991 to 2004 (see Figure 11). Publications in this cluster focus on R&D spillovers from industry-university linkages. At one end of the line, Acs et al. (1994) show that spillovers from universities are important for innovation activities of small firms. Similarly, Mansfield (1991) analyze the extent to which innovations are based on academic research under consideration of the time span between research investment and industrial usage. In addition, Arundel and Geuna (2004) find that public science is one of the most important sources for innovation activities of large European firms. By analyzing the importance of geographical proximity for sourcing public science knowledge, the authors also pay attention to potential effects of knowledge distance. Finally, Mohnen and Hoareau (2003) explore determinants of knowledge sourcing from universities and government labs. They find that particularly R&D intensive firms and radical innovators tend to utilize scientific knowledge. While findings on the importance of scientific knowledge sources for different firm types are mixed, the publications in this cluster generally emphasize the value of academic research as an external source for distant knowledge.

Figure 11: Cluster 9 – Knowledge spillovers from academic research

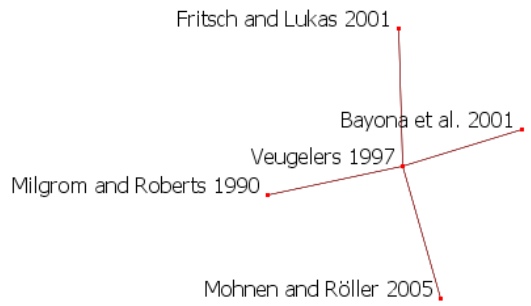


Complementarities in innovation (cluster 10)

Cluster 10 encompasses five publications from the years 1990 to 2005 (see Figure 12). It is a star network with Veugelers (1997) being the central node in the star. As the theoretical foundation of the cluster, the model developed by Milgrom and Roberts (1990) defines the notion of complementarity between activities as a higher marginal impact of adding one activity when the other complementary activity is present. Based on this, the work of Veugelers (1997) discusses the concept of complementarities between in-house R&D and external knowledge linkages in R&D cooperations. Although results are mixed, the importance of effectively linking internal R&D with external knowledge to capitalize on complementarities is generally stated. Closely

related to this, other authors of the cluster analyze complementarities in R&D cooperations with focus on firm motivation and linkage to internal R&D activities (Bayona et al. 2001; Fritsch and Lukas 2001). These publications also show that effective cooperations draw from both systematic internal R&D activities and external sources emphasizing the ability to identify and incorporate relevant external knowledge for innovation. Finally, Mohnen and Röller (2005) focus on complementarities in innovation policies from an industry-level perspective by analyzing different innovation obstacles. As the central aspect of this cluster, the importance of complementarities for innovation activities is emphasized. In the context of external search, firms need to particularly pay attention to the linkage between internal resources and external knowledge in order to be able to fully utilize the complementary potential.

Figure 12: Cluster 10 – Complementarities in innovation



Absorptive capacity (cluster 11)

This cluster comprises five publications between 1999 and 2008 and is structured as a line network (see Figure 13). The focus of the cluster lies on the concept of absorptive capacity as a firm's ability to identify relevant external knowledge, incorporate it and apply it for firm purposes (Cohen and Levinthal 1990). Van den Bosch et al. (1999) discuss the concept with focus on organizational structure and combinative capabilities, namely systems, coordination, and socialization capabilities, for turbulent and stable environments. These capabilities are also in the focus of the analysis of Jansen et al. (2005) who generally confirm a positive relation to a firm's absorptive capacity. Related to this, Vega-Jurado et al. (2008) include a firm's prior knowledge base, formalization mechanisms, and social integration mechanisms as determinants of absorptive capacity in their model. In contrast, the work of Fosfuri and Tribó (2008) focuses on the notion of potential absorptive capacity as a subset of the overall concept that is restricted to the acquisition and assimilation of external knowledge. Findings show that past interaction with external knowledge sources and general experience with external search positively influence a firm's potential absorptive capacity. Finally, Lane et al. (2006) foster a holistic view by conducting a literature review of the field and synthesizing the findings into a model on the process, antecedents and outcomes of absorptive capacity.

Figure 13: Cluster 11 – Absorptive capacity

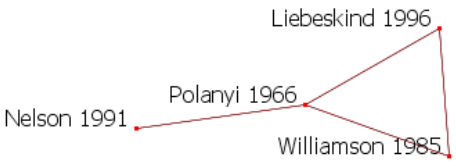
Most relevant for external search, the concept of absorptive capacity emphasizes the need to develop internal capabilities in order to identify and utilize valuable external knowledge and thus, to successfully conduct external search.

Knowledge transfer and protection (cluster 12)

Four publications dating from 1966 to 1996 are included in cluster 12 that focus on the foundations of knowledge transfer and protection (see Figure 14). As part of a complete triad, Williamson (1985) discusses the concept of

transaction cost economics stating that actors engaged in exchange relationships are assumed to be subject to bounded rationality and guided by opportunistic behavior, which needs to be taken into account in the case of organizational transactions. Explicitly focusing on knowledge transfer, Liebeskind (1996) discusses institutional capabilities of firms such as incentive- and employment-related mechanisms that enable the protection of knowledge against expropriation and imitation. In this context, Polanyi (1966) highlights the tacit dimension of knowledge, which makes it difficult to transfer knowledge but also prevents other organizations from becoming aware of potentially valuable knowledge. Brokered by Polanyi (1966) with high centrality values, the work of Nelson (1991) is attached to the outlined triad. The author reviews various perspectives on firm differences and heterogeneity in the context of innovation. He argues that competitive advantage is based on organizational differences with respect to the ability to create and exploit innovations and thus, is a function of internal capabilities. This cluster therefore is particularly focused on the notion of developing and protecting internal knowledge and capabilities to maintain a certain advantage in the market. In the context of external search, this view is extended by emphasizing the need of firms to open up and span their boundaries to explore valuable external knowledge. While this knowledge is principally available to all firms, the focus shifts to the need to develop internal capabilities for identifying and utilizing external knowledge for innovation (Cohen and Levinthal 1990).

Figure 14: Cluster 12 – Knowledge transfer and protection

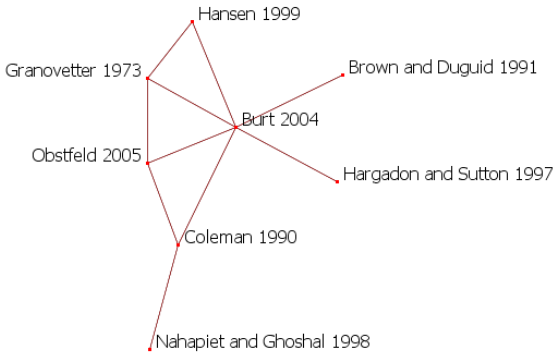


Social networks (cluster 13)

Cluster 13 includes eight publications from the years of 1973 to 2005 and focuses on the theory of social networks (see Figure 15). The overall cluster is structured as a star network involving some additional triads. As the central node in the network with highest degree and betweenness centrality, the work of Burt (2004) functions as a bridge between the other publications in the network. The publication focuses on the mechanism of brokerage in social networks by analyzing networks around managers in large U.S. companies. Findings indicate that people who are connected between groups are more likely to think in alternative ways and express creative ideas. Adopting a firm-level view, Hargadon and Sutton (1997) analogically discuss the role of technology brokering where a firm utilizes its network position to enable the development of innovative products. As the foundation of this, Granovetter (1973) discusses interpersonal ties with respect to strong and weak ties in social networks emphasizing the importance of weak ties for a person's opportunities and integration into communities. Hansen (1999) transfers the notion of weak ties to the company setting to explain knowledge sharing across organizational subunits. He shows that weak inter-unit ties support the search for relevant knowledge in R&D projects when knowledge is not complex. Similarly, the work of Obstfeld (2005) is focused on the differences between dense and sparse networks for innovation activities indicating that individuals with dense networks, among other factors, tend to have a higher involvement in innovation activities. In the context of organizational learning, it is also stated that informal, fluid communities of practice, sometimes involving outside actors, foster learning and innovation in an organization (Brown and Duguid 1991). From a general social theory view, Coleman (1990) develops the concept of social capital as an asset embodied in the relations among persons. Brokered by

Coleman (1990) with a high betweenness centrality value, the work of Nahapiet and Ghoshal (1998) focus on social capital as an enabler for intellectual capital of organizations. They therefore highlight the importance of networks and relationships as a valuable resource in order to improve the organizational knowledge capability. While this cluster has its origins in sociological theory, it also provides important insights for the external search literature by emphasizing the value of networks and weak ties for gaining new, potentially unconventional knowledge. This body of literature therefore stresses the need to not only rely on the direct periphery of relationships but also to include more distant or loosely connected actors when searching for diverse knowledge.

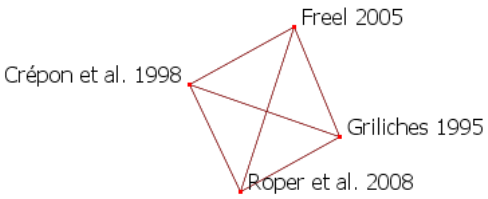
Figure 15: Cluster 13 – Social networks



Innovation and productivity (cluster 14)

The cluster on innovation and productivity (see Figure 16) represents a complete network where each node is connected with every other node (De Nooy et al. 2005). It is therefore a network with maximum density consisting of four publications from the years of 1995 to 2008. Crépon et al. (1998) study the links between productivity, innovation and research. Findings indicate that innovation output increases with research effort and firm productivity is positively correlated with innovation output. Similarly, Griliches (1995) reviews different attempts to assess the contribution of R&D to economic growth and especially pays attention to R&D spillovers as a source for increased innovation productivity. Adopting a more fine-grained view, Roper et al. (2008) evaluate the innovation value chain of knowledge sourcing, transformation, and exploitation to identify drivers of innovation and productivity. They especially show the importance of different knowledge sourcing activities for a firm's innovation activities resulting in increased firm performance. Finally, Freel (2005) investigates the relationship between innovativeness and labor quality by analyzing employee skills and organizational training activity.

Figure 16: Cluster 14 – Innovation and productivity



In highlighting the importance of innovation for a firm's performance in terms of growth and productivity, this cluster provides the basis for justifying activities that lead to improved innovation performance. From a general perspective, it can be argued that external search activities need to be shaped in such a way that they provide value for the organization.

4.2 Current research focus and dimensions of external search

A systematic content analysis of the 108 publications from the core dataset serves as basis for deriving the current focus of the research field. The entire list of publications with respective classification according to the analyzed categories can be found in the appendix (see Table 6 and Table 7). Descriptive analysis of the distribution of publications across publication years (see Figure 17) shows that attention started to increase in 2010 and accelerated in 2013 with a preliminary peak in 2014. Overall, about 55% of publications in the analyzed dataset have been published between 2013 and 2015. Since the open innovation area constitutes an important theoretical foundation

of current work on external search, the increased attention can be attributed to the preceding growth of open innovation literature (Dahlander and Gann 2010) amplified by special issues in journals such as Research Policy and R&D Management. Analysis of the distribution across journals shows that contributions in the field is spread across a total of 50 journals covering various discipline areas. However, more than 53% of publications are published in ten journals only (see Table 3). With one exception, these are all highly rated academic journals with an overall rating of 3 or more[7]. With regard to the discipline area, a significant proportion of literature in the research field (39.8%) is published in journals with an innovation focus such as Research Policy, Technovation, and R&D Management.

Table 3: Journal distribution of publications in core dataset (own analysis)

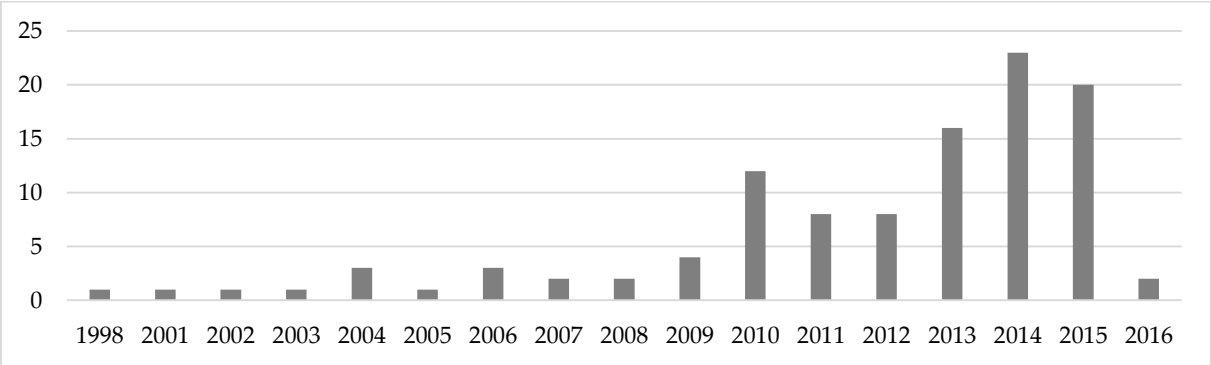
Journal	Publications No.	%
Research Policy	10	9.26
Strategic Management Journal	9	8.33
Technovation	8	7.41
Technology Analysis and Strategic Management	6	5.56
R&D Management	6	5.56
Journal of Business Research	4	3.70
Industrial and Corporate Change	4	3.70
Journal of Product Innovation Management	4	3.70
Academy of Management Journal	4	3.70
Industrial Marketing Management	3	2.78
Other[8]	50	46.30
Total	**108**	

Research focus

The strong focus on the innovation area is confirmed when analyzing the content of the publications in the dataset. While 92.6% are located in the area of innovation management, only 7.4% focus on general management- and strategy-related topics such as corporate strategy, turnaround, and decision-making (e.g., Adebe 2012; Bennett 2005; Morris et al. 2014).

A similar pattern can be derived based on the examined search focus of the publications: 84.3% focus on the search for innovations such as new product ideas (e.g., Katila and Ahuja 2002; Laursen and Salter 2006), product or business improvements (e.g., García-Granero et al. 2014; Guo 2009), and knowledge required in different phases of the innovation process (e.g., Feng et al. 2014; Horváth and Enkel 2014).

Figure 17: Number of publications across years (own analysis)



[7] Rating according to AJG (2015)

[8] Journals with only one or two publications each

Closely related to this, two publications discuss the search for market opportunities in order to commercialize existing technologies (Gruber et al. 2013; Keinz and Prügl 2010). In a much broader view, other papers focus on the search for general problem solutions (e.g., Afuah and Tucci 2012; Morris et al. 2014) and knowledge for decision support (e.g., Ammetller et al. 2014; Pineda et al. 1998). Finally, four papers examine the search for environmental discontinuities related to opportunities and threats based on shifts in the technological, market or regulatory environment (e.g., Bessant 2008; Liu et al. 2013). While the majority of papers in the external search field focuses on the search for innovations, the latter group can be regarded as most relevant for the research interest of this paper. By analyzing external search for discontinuities and trends in the environment, these publications follow a long-term forward-looking search approach as related to the search in the context of foresight. However, with only 3.7% this research focus is so far rather underrepresented in the analyzed literature.

With respect to methodology-related aspects, the majority of publications employ empirical methods to analyze external search-related aspects. Here, statistical sampling represents the predominant method (83.3%) while only 7.4% of the publications use case studies. Analytical methods are less used with 7.4% conceptual and 1.9% mathematical approaches. Thus, the focus of the research field lies on quantitative, theory testing methods. The sample size hereby varies significantly from very small samples of below 100 (e.g., Britton 2004; Noseleit and De Faria 2013) to very large samples of more than 3.000 using data from national innovation surveys (e.g., Köhler et al. 2012; Mol and Birkinshaw 2009). Evaluation of the industry distribution of the empirical studies shows that more than half of the papers (53.1%) focus on a single industry with manufacturing as the highest ranked industry (36.1%). In contrast, 38.4% of the empirical studies include multiple industries in their sample allowing for cross-industry comparability of results. The majority of publications focus on the firm as the unit of analysis (84.3%) enabling a holistic view on the impact and determinants of organizational search activities. Only a small portion of studies focus on projects (4.6%) or individuals in an organizational context (11.1%).

Dimensions of external search

According to RQ 3 a further research interest lies in the analysis of dimensions of search strategies that impact a firm's external search. Focusing on empirical research in the dataset, the content analysis shows seven dimensions that can be grouped into two major categories. Table 4 provides an overview of the dimensions and the corresponding publication distribution. The majority of publications focus on dimensions related to the *search scope* of external search strategies. Here, the *breadth of external search* is discussed by 51 papers, which therefore constitutes the dimension that has received the highest attention in the analyzed literature. Laursen and Salter (2006) define external search breadth as "the number of external sources or search channels that firms rely upon in their innovative activities" and later as a "range of different sources or channels" (Laursen and Salter 2014). The dimension thus focuses on the extent to which different external sources are used for a firm's search activities, which is associated with the diversity of external sources. This dimension is typically operationalized as the count of different types of external sources based on a subjective assessment of survey respondents (e.g., Laursen and Salter 2014), or the count of patents that cite different types of external sources (e.g., Argyres and Silverman 2004). Breadth of search enables access to a large and diverse knowledge pool fostering the detection of potentially new and distinctive ideas or solutions (Dahlander et al. 2014; Leiponen and Helfat 2010).

Table 4: Overview of dimensions of external search strategies (own analysis)

Category	Dimension	Description	No. of publications
Search scope	Breadth of external search	Diversity of external sources, i.e. use of different types of sources	51
	Depth of external search	Intensity of external search, i.e. time and resources allocated to external search	37
	Direction of external search	Orientation of external search activities towards exploration or exploitation of knowledge	9
Search distance	Technological distance of external search	Technological distance between knowledge of focal firm and external knowledge sources	18
	Geographical distance of external search	Geographical distance between the focal firm and external knowledge sources	10
	Temporal distance of external search	Recency of external knowledge searched by focal firm	2
	Relational distance of external search	Relationship between focal firm and external knowledge sources	3

By accessing a broad range of different knowledge sources, a firm may improve the likelihood of discovering knowledge that will match its knowledge requirements (Leiponen and Helfat 2010). Moreover, searching broadly will provide access to alternative perspectives that can help to identify opportunities for transferring knowledge from one domain to another (Schilling et al. 2003). However, since broad search might reveal knowledge that has a small overlap to the existing internal knowledge base of the searching firm, it can be difficult for the firm to integrate and apply this knowledge (Cohen and Levinthal 1990). Moreover, conducting a broad search over different types of external sources requires significant effort and time to learn how to retrieve knowledge from the various sources (Laursen and Salter 2006). Thus, firms may experience increased costs due to the need to manage both the variety of knowledge and the relationships to the associated sources (Leiponen and Helfat 2010). As a means of balancing the diversity of external sources and the associated costs, a few authors propose to specialize search strategies with respect to the firm's knowledge needs by utilizing market-, science- or supply-driven search strategies (e.g., Ritala et al. 2013; Sofka and Grimpe 2010).

In contrast, the *depth of external search* is defined as the degree, or intensity, to which external knowledge sources are used (Chiang and Hung 2010; Katila and Ahuja 2002). This dimension is studied in 37 publications of the dataset, where it is typically operationalized by the amount of time, effort, or resources allocated to external search, or the frequency of using external sources (e.g., Bennett 2005; Dahlander et al. 2014; Guo 2009; Lee et al. 2011). Intensively utilizing external knowledge sources requires firms to build and maintain strong and frequent contacts with these sources including defined patterns of interaction (Laursen and Salter 2006). This facilitates the transfer of in-depth knowledge leading to potentially well-defined solutions or ideas (Chiang and Hung 2010; Schilling and Green 2011). Moreover, building close relationships with external sources enables the development of routines and reduces the likelihood of tapping into false signals or retrieving unsuitable knowledge input, making the search more reliable and predictable (Katila and Ahuja 2002; Levinthal and March 1981). On the other hand, excessive depth in external

search can also have negative effects. Literature demonstrates the risk of organizational rigidity when relying exclusively on a limited number of intensively used knowledge sources (Leonard-Barton 1995). Additionally, maintaining close relationships with external sources requires resources and attention by the searching firm. According to the attention-based theory, attention of decision makers within firms is limited and needs to be selectively focused on certain aspects while ignoring others (Ocasio 1997; March and Olsen 1976). Thus, it may be necessary for firms to limit close contacts to a small number of external sources only (Chiang and Hung 2010) as the level of search needs to be matched with the firm's capacity to process the retrieved knowledge (Cohen and Levinthal 1990; Koput 1997).

A final dimension with respect to the scope of search constitutes the *direction of external search*, which is explicitly discussed in nine publications. It is concerned with the question whether external search is conducted with the aim to exploit existing knowledge or to explore new knowledge. This dimension is operationalized by a subjective assessment of survey respondents on the extent of using external sources for exploration-related and exploitation-related purposes (e.g., Clausen et al. 2013; García-Granero et al. 2014). In the external search literature, the distinction between exploitative and explorative search is also discussed along with the dimensions of search breadth and depth, where breadth is associated with an explorative direction and depth with an exploitative direction (e.g., Katila and Ahuja 2002). However, with respect to the research interest of identifying relevant dimensions of external search strategies from the literature, the direction of search is discussed as a separate aspect in the following. External search directed towards exploitation involves the use of knowledge that is close to the firm's knowledge base to enhance existing capabilities (Clausen et al. 2013; García-Granero et al. 2014). It is associated with incremental learning where a firm searches its neighborhood to extend the current knowledge base (Rosenkopf and Nerkar 2001). According to evolutionary theory, exploitation is targeted at the refinement and extension of existing competencies and is thus, more proximate and predictable for firms (Levinthal and March 1993; March 1991). On the contrary, exploitative search poses the risk of core rigidities, as the firm is not able to adapt to advances in different fields than its current core capability (Bierly and Chakrabarti 1996). External search directed towards exploration involves the use of external knowledge that is different from the firm's current expertise to identify radically new ideas or solution knowledge (Clausen et al. 2013; García-Granero et al. 2014). It is driven by the desire to discover something new and can provide the basis for a further exploitation of discovered opportunities (Levinthal and March 1993; Rothaermel and Deeds 2004). However, explorative search involves higher uncertainty, longer time horizons, and more diffuse outcomes (March 1991). It includes high costs related to experimentation and risk associated with the identification and integration of unfamiliar knowledge (Bierly and Daly 2007; March 1991). Since exploitation usually generates results that are clearer and closer to current practices, firms tend to focus predominantly on this type of search (Levinthal and March 1993). However, the literature highlights the importance of maintaining a balance between the two directions in order to ensure long-term success of organizations (Levinthal and March 1993; March 1991).

Further, the concept of local and distant search, which is closely related to the notion of exploration and exploitation, is discussed in the literature. While local search refers to the search for familiar knowledge that is proximate to the firms current knowledge base, distant search focuses on unfamiliar and remote knowledge (Li et al. 2008; Rosenkopf and Almeida 2003;

Rosenkopf and Nerkar 2001). In this context, further dimensions focus on the *search distance* in external search strategies. Distance can be defined based on the boundaries of the firm, where local search is typically associated to searching within firm boundaries and distant search to searching outside firm boundaries or boundary-spanning search (Rosenkopf and Nerkar 2001). With respect to the context of this paper, external search already involves a form of boundary-spanning search, namely the search outside of the organizational boundaries of the firm (Felin and Zenger 2014; Rosenkopf and Nerkar 2001). In addition to this organizational boundary-spanning search, a further dimension is discussed in the literature related to the *technological distance of external search*, which is examined in a total of 18 publications. This dimension focuses on the similarity of technological domains of the searching firm and external sources. This dimension us operationalized by matching the technological fields of knowledge, patents or portfolios of the focal firm and its external knowledge sources (e.g., Cantwell and Zhang 2013; Jiang et al. 2010; Vasudeva and Anand 2011). By conducting technologically local search, the firm focuses on similar technology resulting in knowledge that is close to the firm's existing knowledge base (Rosenkopf and Almeida 2003; Wagner et al. 2014). Hence, this type of search is typically associated with incremental innovation with the threat of potentially constraining the direction of a firm's R&D activities (Martin and Mitchell 1998; Stuart and Podolny 1996). On the contrary, technologically distant search involves search in technological areas that are new to the firm to expand the current knowledge base and to detect emerging new developments (Jiang et al. 2010). Technological distance is closely related to the dimension of search breadth as different types of external sources tend to have different technological skills and capabilities with a varying degree of technological distance of knowledge (Chen et al. 2011; Jiang et al. 2010).

Other studies point to the relevance of the *geographical distance of external search*, which is analyzed in ten publications of the dataset. This dimension is operationalized by matching the geographical location of the focal firm and its external knowledge sources (e.g., Capaldo and Messini Petruzzelli 2015; Rosenkopf and Almeida 2003). Literature indicates that firms tend to search in geographically proximate areas, which is attributed to reduced costs and increased frequency of contact based on interfirm linkages between firms in a region (Rosenkopf and Almeida 2003; Saxenian 1990). Knowledge gained from geographically close sources involves typically less integration effort as a common regional context implies shared values and knowledge evolvement mechanisms (Phene et al. 2006). However, geographically distant search grants access to a more diverse environment with different actors, challenges and demands (Wu and Wu 2014). Phene et al. (2006) point to the fact that due to different perspectives and cognitions, actors in geographically distant areas may utilize the same knowledge piece in new ways. On the contrary, these benefits are potentially surpassed by the involved costs associated with the effort to understand and integrate geographically distant knowledge (Capaldo and Messini Petruzzelli 2015).

In addition to the above outlined, highly discussed aspects, two publications in the dataset point to the concept of *temporal distance of external search* focusing on the age of the externally sourced knowledge. Literature operationalizes this dimension by quantifying the number of years between patent publishing and the in-licensing of the relevant knowledge (Li-Ying et al. 2014) or as the difference between publication year of citing and cited patents (Cantwell and Zhang 2013). In order to solve problems, firms tend to search for most recent knowledge based on the assumption that knowledge creation follows an evolutionary process where the most recent knowledge is

understood as the best representative compared to alternatives (Li-Ying et al. 2014; Nerkar 2003). By focusing on recent knowledge, firms are able to maintain fit to the changing environment and to better predict future technological advances (Katila 2002). Additionally, since more recent knowledge is usually closer to the firm's current knowledge base, organizational routines can be utilized resulting in less errors as compared to a trial-and-error search process (Nerkar 2003). In contrast, older knowledge is usually considered to be more reliable (March 1991) and increases the likelihood of gaining unique insights compared to the competition since it is difficult to access and build upon and thus, provides a rare resource (Barney 1991; Katila 2002). In this way, firm's may be able to gain benefits from reusing old knowledge by evaluating previously disregarded knowledge in new light (Nerkar 2003).

Finally, three publications study the dimension of *relational distance of external search*, which emphasizes the importance of relationships when searching and transferring knowledge from external sources. This dimension is based on the notion that the relation between actors involved in knowledge transfer affect how the knowledge is perceived and processed (Menon and Blount 2003). Here, Piezunka and Dahlander (2015) discuss the notion of personal distance indicating that external sources that have interacted with a firm in the past are more likely to receive attention from that firm in the future. Similarly, King and Lekse (2006) distinguish between known external sources, such as personal contacts to outside experts, and unknown external sources, such as contacts via the internet. In the context of external search distance, known sources can be attributed to relationally local search as relationships typically evolve around common interests with similar expertise (Rosenkopf and Almeida 2003). In contrast, unknown sources can be associated with relationally distant search, which involves a higher probability of gaining new insights but also increased search costs (Bauer and Gegenhuber 2015). From a different view, Jeppesen and Lakhani (2010) emphasize the relations among knowledge sources and discuss the advantage of social marginality for generating new and novel solutions in an innovation contest. While the publications in this dimension involve rather heteroges approaches, they all show the importance of relational aspects when engaging in external search activities.

5 Discussion

5.1 Identification of research gap

Co-citation and content analysis reveal the structure and current research focus of literature on external search behavior. The intellectual structure of the field is shaped by two major research streams, namely external search and innovation as well as knowledge transfer and integration. However, theoretical foundations of organizational search and learning are underrepresented. This indicates a weak link of current literature on external search with general organizational theory and especially organizational learning and search. From a structural perspective, cluster analysis indicates that the intellectual field is characterized by a certain degree of fragmentation involving several diverse subfields with no superposition or strong bridging papers between clusters. As fragmentation may bear the risk of compromising the future of a research field as a unique discipline (Di Guardo and Harrigan 2012), future research in this area should aim to establish links between the different perspectives to enable a more holistic view on the research field. From a content perspective, current research on external search is strongly focused on the innovation area, as indicated by the cluster distribution, journal focus, and research discipline of the analyzed papers. Originating from the evolvement of open and user innovation, the current research on external

search for innovations provides valuable insights with respect to determinants and the impact of different search strategies. In this context, literature focuses on external search activities directed towards the identification of new product ideas or problem solutions throughout the innovation process (e.g., Laursen and Salter 2006; Horváth and Enkel 2014). Literature on external search for environmental discontinuities and trends is so far underrepresented in the research area. However, foresight literature emphasizes the need to develop a forward-looking, proactive search capability by utilizing external knowledge sources in order to identify future developments and direct a firm's innovation activities (Becker 2002; Rohrbeck et al. 2015). Since foresight activities are characterized by a long-term orientation and high uncertainty, the search for discontinuities and trends may require different search strategies as opposed to the search for innovations. So far, it is poorly understood how firms need to shape their search activities in order to utilize external knowledge sources for foresight. In the following we therefore focus on discussing the general findings from the review of the external search field with respect to their relevance for external search in the foresight context.

5.2 Implications on external search for future discontinuities and trends

Based on the identified clusters in the research field, a number of areas can be retrieved that are deemed relevant for the context of foresight. First, the value and suitability of different external knowledge sources for enhancing a firm's existing knowledge base is emphasized (see clusters 2, 3, 4, 6, and 9). While the majority of publications in the clusters focus on innovation-related search, general findings are expected to be relevant for foresight-related search activities. In the foresight literature, the use of external knowledge has been considered important for identifying potential future developments (Becker 2002; Hiltunen 2008). However, cluster analysis reveals that the suitability of different types of external sources might vary according to firm context or knowledge requirements, indicating the need to selectively adjust search strategies rather than to apply a one-size-fits-all approach (see clusters 6 and 7). Consequently, it seems to be important to consciously evaluate which external sources should be included when searching for discontinuities and trends in the firm environment. Related to this, analysis shows the relevance of search distance, i.e. whether external search is focused on the immediate neighborhood of a firm or on areas that are more distant (see clusters 1, 5, and 9). In the context of corporate foresight, literature stresses the importance to reduce the risk of blind spots by expanding the scope of investigation towards the periphery (Day and Schoemaker 2004; Slaugther 1997). Hence, paying attention to the proximity of search areas can be considered important when evaluating search strategies for foresight.

Results further indicate the role of complexity and uncertainty of the solution landscape for conducting efficient search (see clusters 4 and 5). It is shown that complex environments make it difficult to find high-value solutions (Kauffman 1993; Levinthal 2001) and problems with high uncertainty benefit from an increased number of solvers (Boudreau et al. 2011). As the search for future developments is characterized by a high degree of uncertainty, it can be assumed that efficient search strategies in this context differ from those applied for areas that are more clearly defined. Drawing from the findings of the content analysis, a number of dimensions need to be considered that might be of relevance for shaping the external search strategy in the context of foresight. We thus propose that in order to successfully identify potential future discontinuities and trends, firms need to determine the optimal search strategy with respect to the scope and distance of external search.

Scope of external search for discontinuities and trends

Former analysis shows that a broad external search involving different types of knowledge sources enables firms to access a diverse knowledge pool. As different external sources may provide distinct knowledge, the likelihood increases to detect relevant new insights. The dimension of external search breadth is thus expected to be highly relevant for the context of foresight as different perspectives enable a broad search for potential discontinuities and trends. Due to high uncertainty of future developments, threats from outside the firm domain become more likely requiring a broader search scope with a variety of sources (Day and Schoemaker 2004; Hiltunen 2008). This is based on the assumption that knowledge about future developments is broadly distributed over different knowledge sources (Miles and Saritas 2012). With respect to the different types of external sources, market-related sources such as customers or competitors may provide insights into future needs and long-term shifts of market demands (Feng et al. 2014; Köhler et al. 2012). Especially lead users can be expected to be a valuable source for identifying early signals of future trends (see cluster 3). Here, foresight literature highlights the importance to look beyond a firm's existing customer base in order to uncover market-related signals outside the firm's core business (Harris and Zeisler 2002). As foresight activities are usually characterized by a long-term horizon, the role of scientific-related knowledge sources such as universities and research labs can be expected to be particularly important (see cluster 9) since the long-term orientation of academic research might provide indications on potential emerging opportunities (Sofka and Grimpe 2010).

While external search breadth is expected to enable a broad view on discontinuities and trends, it might be difficult for firms to understand and assess their relevance. Findings from current literature point to the importance of external search depth as a way to transfer in-depth knowledge for a more detailed understanding of potential implications. A future-oriented view requires to look in depth in order to identify those signals that are relevant to the firm (Godet and Roubelat 1996). Thus, the dimension of external search depth is deemed relevant in the context of foresight. However, foresight literature points to a trade-off between breadth and depth. As deep external search, e.g. by means of face-to-face interactions in discussion workshops, allows for in-depth thinking and knowledge transfer, it constrains at the same time the breadth of search (Cachia et al. 2007; Piirainen et al. 2012). As a means to enable both broad search and utilizing in-depth knowledge from selected types of external sources, specialized search strategies are discussed in the literature (see cluster 6). In consequence, while depth of external search is expected to be important for identifying and understanding future developments, particular attention needs to be given to identifying the optimal degree of search depth.

Further, analyzed literature points to the direction of external search as a dimension of search strategies. Since the search in the early phase of foresight is directed towards discovering new knowledge relating to potential future developments, it is associated with exploratory search as opposed to exploitative search, which is directed towards the use and development of already existent knowledge (Levinthal and March 1993; March 1991). Accordingly, the primary interest of foresight lies on the detection of novel discontinuities as opposed to familiar ones, since the former constitute new, emerging trends that bear strategic surprises (Ansoff 1983; Liebl and Schwarz 2010). In that way, corporate foresight contributes to the process of exploratory learning and adaption (McGrath 2001; Paliokaite 2012) and aims to explore a range of possible but uncertain futures (Godet 1986). Thus, it can be stated that the search for discontinuities and trends is associated with the direction of

exploration rather than exploitation. However, exploratory search is especially focused on the initial phase of foresight. In order to derive value from foresight activities, results from the initial search need to be interpreted, translated and utilized with respect to implications for the focal firm (Horton 1999; Paliokaite 2012). The subsequent steps within the foresight process therefore also involve exploitative activities, which emphasizes the importance of maintaining balance between the two directions (Levinthal and March 1993). Since the research interest of this paper lies on the initial phase, the dimension of external search direction is assumed to be less relevant.

Distance of external search for discontinuities and trends

Early signs of discontinuities and trends typically originate outside a firm's area of expertise (Harris and Zeisler 2002). Thus, firm's need to search beyond their direct knowledge domain to uncover relevant signals. The analysis reveals that technological distance of external search enables firms to expand their knowledge base to detect new insights from distant knowledge areas. By searching in other industries or peripheral groups that are not directly related to the firm's core business, a firm reduces the risk of blind spots and increases the likelihood to detect future developments (Day and Schoemaker 2004; Paliokaite et al. 2014). This may be related to new emerging technologies or converging industries that offer opportunities for firms to reshape their value chain when detected early (Prahalad 2004). Search beyond the technological boundaries of the firm usually requires paying attention to signals that are deemed irrelevant in light of the present knowledge base, but may be of importance in the future (Haeckel 2004). Thus, it can be assumed that technological distance of knowledge sources is important for the search in the context of foresight.

The dimension of geographical distance can also be expected to be relevant. Similar to searching in technological distant areas, it might be important to look beyond the geographical area of the firm for indicators of future developments. Foresight literature points to the need to search in distant markets and countries to identify potential shifts that may constitute opportunities or threats for the future business of the firm. Here, discontinuities and trends may evolve around economic developments, shifts in power distribution or preferences (Harris and Zeisler 2002). Moreover, Prahalad (2004) emphasizes the importance of looking beyond a firm's geographical boundary to identify new opportunities in distinct markets. He argues that paying attention to fundamentally different geographical markets enables firms to question their current view on competition and value creation to rethink the logic of their business.

The role of temporal distance for external search in the context of foresight is assumed to be rather limited. Since foresight aims to identify potential future developments, search activities will be typically focused on recent knowledge rather than reexamining old, previously disregarded knowledge. In fact, exclusively relying on old knowledge instead of identifying new knowledge related to future states has been identified as a barrier for foresight activities (Öner and Göl 2007). It can therefore be inferred that temporal distance is less relevant for uncovering future discontinuities and trends.

Finally, findings point to the role of the relational dimension of external search. Current literature stresses the importance of personal knowledge sources for conducting foresight activities as compared to impersonal contacts (Becker 2002; Hiltunen 2008). Emphasizing the personal connection, studies have shown that business managers traditionally rely on personal, informal sources when searching for environmental changes (Brush 1992; Johnson and Kuehn 1987). Due to personal links, these sources provide strong signals usually related to already known areas (Julien et al. 2004). However, valuable new knowledge that enables

the detection of discontinuities and trends often evolves from unknown knowledge sources. For example, research centers and universities constitute an external source with which firms have usually little direct contacts (Hiltunen 2008; Julien et al. 2004). Moreover, so-called weak tie networks enable the identification of signals from different directions by utilizing indirect, temporary contacts in the network (Smedlund 2008). Recent open innovation literature also discusses crowdsourcing-related approaches that emphasize the role of a broad mass of unknown, external actors as a means to gather radical new insights (see cluster 4). In consequence, the degree of relational distance is deemed important in the context of foresight.

6 Conclusion

6.1 Summary of findings

By means of a co-citation and content analysis, this paper systematically analyzes the intellectual structure and current research focus of the external search field to identify relevant research streams and theoretical concepts applicable for external search in the context of corporate foresight. From a general perspective, analysis reveals a certain fragmentation of the research field and an underrepresentation of theoretical foundations in the area of organizational learning and search. Further, a strong focus of the research field on the search for innovations is identified. While findings within this stream are found to be applicable as a basis for further investigating external search for the context of foresight, it is shown that a knowledge gap exists addressing different external search strategies for identifying future discontinuities and trends. It is proposed that in order to successfully identify future developments, firms need to define their search strategy with respect to the scope and distance of external search. Based on a content analysis, a number of dimensions are retrieved that need to be considered when shaping a firm's external search strategy. With respect to the scope of external search, particularly the breadth and depth of search are deemed relevant for the search for the context of foresight. Considering the distance of external search, the dimensions of technological, geographical and relational distance are expected to be important when searching for future discontinuities and trends.

6.2 Implications for future research

This study contributes to research on external search as well as to the field of corporate foresight. With respect to future research in the area of external search, co-citation analysis reveals the intellectual pillars and network structure of the research field providing important insights into central concepts and authors, relationships and predominant theoretical streams. The identified fragmentation of the field points to the need for future research to establish links between the concepts and subgroups in order to draw more holistically from the various theoretical streams in the research field. Moreover, fundamental works on organizational learning and search originating from organizational theory are so far represented to a limited extent only. Linking future research on external search even more strongly with general organizational theory might generate new perspectives and provide the basis for broader applicability of findings. In that way, contemporary research on open innovation could even stronger benefit from traditional theories of organizational learning and search.

Regarding future research in the field of corporate foresight, this study highlights the potential of linking foresight research, and particularly the search for future discontinuities and trends, with general organizational search behavior. Research in the field of foresight has been criticized for its lack of theoretical underpinnings and linkages to general management research (Öner 2010; Rohrbeck et al. 2015). By showing the relevance of external search theory for identifying early signs of

future developments, this study offers a broader perspective for future research in the field of foresight, which may benefit from a stronger embedding in organizational theory. Further, concrete dimensions of external search strategies are revealed that are deemed relevant for the search in the context of foresight. Following the recommendation of Rohrbeck et al. (2015) to empirically investigate foresight activities in the light of forward-looking search, the findings of this paper can be used as a starting point to evaluate different search strategies and their impact on identifying future developments in the firm context. In order to assess potential performance impacts, future research needs to define appropriate measures for the value contribution of foresight, which is deemed difficult due to its long-term orientation (Barré and Keenan 2008; Horton 1999). However, a few approaches for measuring the contribution of foresight exist (e.g., Amsteus 2011; Johnston 2012; Rohrbeck and Gemünden 2011) that might provide the basis for further investigating the impact of external search strategies in the context of foresight. With respect to the findings of this paper, further analysis is required to shed light on the optimal balance between breadth and depth of external search to detect future developments. Another relevant question that needs to be addressed is whether 'oversearching' might have negative effects on the identification of early signs of future developments as newly gained knowledge needs to be absorbed by the organization. Finally, findings reveal benefits and costs of distant search with respect to technological, geographical and relational distance. Future research needs to be conducted to investigate the optimal degree of distance for exploration of future discontinuities and trends. By evaluating different external search strategies, future research may provide guidance as to how (scope) and where (distance) to externally search in order to detect discontinuities and trends in the firm environment.

6.3 Practical implications

Findings of this paper provide some interesting insights for practitioners. First, the discussion on relevant dimensions of external search strategies can provide initial guidance as to which aspects need to be considered when searching for long-term future developments in an uncertain environment. By defining the scope and distance of search, managers can shape the external search strategy according to their specific knowledge needs. It is indicated that a broader and more distant search may provide knowledge that is new to the firm and covers various perspectives on potential future opportunities and threats. However, further research needs to be conducted in this area in order to determine the impact of the scope and distance of external search for identifying future developments.

Second, analysis points to the importance of matching external knowledge search with internal capabilities in order to be able to fully exploit retrieved knowledge (see e.g. clusters 1, 2, 10, and 11). While the focus of this paper lies on the initial phase of foresight with respect to exploring new knowledge on future developments by external search, firms need to ensure that the internal organization is able to absorb this knowledge in a way that concrete actions can be derived (Cohen and Levinthal 1990; Paliokaite 2012). This implies that managers not only need to pay attention to the optimal search strategy, but also to build up organizational capabilities and institutional structures that enable the exploitation of retrieved knowledge on future discontinuities and trends.

6.4 Limitations and outlook

While the findings of this paper provide important insights for research and practice, they involve also some limitations. With respect to the methodological approach, it needs to be noted that analysis of the core dataset, selection of thresholds, and interpretation of results may involve subjective bias due to a single

researcher. Further, only those publications have been included in the analysis that met the chosen search phrase in the selected databases. It is therefore conceivable that other relevant publications in the examined area exist, which haven't been included in the analysis. However, the aforementioned limitations have been aimed to be minimized by ensuring a systematic, rule-guided and transparent research process as outlined in the methodology section.

The conducted analysis reveals relevant research streams and search dimensions for external search in the context of foresight. Yet, results are based on theoretical analysis of current research only and therefore need to be cautiously applied. Hence, further empirical investigation is required in order to detail and validate the findings in light of data from organizational practice. For this, the paper provides valuable insights with respect to relevant dimensions of external search strategies for the search for future developments as a starting point for future empirical research.

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8 Appendix

Table 5: Coding scheme for content analysis of core dataset

Category	Coding	Reference
Research method	Analytical-conceptual Analytical-mathematical Analytical-statistical Empirical-experimental design Empirical-statistical sampling Empirical-case studies	Research method according to taxonomy developed by Wacker (1998)
Research area	Corporate decision making and problem solving Corporate strategy Corporate turnaround Innovation management	Research discipline adjusted from classification approach of Lyles (1990)
Level of analysis	Firm Project Individual	Level of research analysis as used e.g. by Li et al. (2008)
Sample size	-	Sample size of empirical analysis (if appropriate)
Industry	Arts Education Health Care Information Technology Manufacturing Services Multiple	Analyzed industry (if appropriate); categories following NAICS (2016) classification
Search focus	Decision support Environmental discontinuities Innovation Market opportunities Problem solutions	Deductively derived from analyzed core dataset
Search dimension	Breadth Depth Direction Technological distance Geographical distance Temporal distance Relational distance	Deductively derived from analyzed core dataset

Table 6: Overview classification core publications – research method, research area, level of analysis, sample size and industry

Publication	Research method	Research area	Level of analysis	Sample size	Industry
Adebe 2012	Empirical - statistical sampling	Corporate turnaround	Firm	N = 70	Manufacturing
Afuah and Tucci 2012	Analytical - conceptual	Corporate decision making and problem solving	Firm	-	-
Alguezaui and Filieri 2010	Analytical - conceptual	Innovation management	Firm	-	-
Almirall and Casadesus-Masanell 2010	Analytical - mathematical research	Innovation management	Firm	-	-
Ammetller et al. 2014	Empirical - statistical sampling	Innovation management	Individual	N = 126	Not specified
Argyres and Silverman 2004	Empirical - statistical sampling	Innovation management	Firm	N = 31,232 patents	Multiple
Azagra-Caro et al. 2014	Empirical - statistical sampling	Innovation management	Firm	N = 1.031	Manufacturing
Bauer and Gegenhuber 2015	Analytical - conceptual	Corporate decision making and problem solving	Firm	-	-
Belussi et al. 2010	Empirical - statistical sampling	Innovation management	Firm	N = 78	Health Care
Bennett 2005	Empirical - statistical sampling	Corporate strategy	Firm	N = 141	Arts
Bergendahl and Magnusson 2015	Empirical - statistical sampling	Innovation management	Individual	N = 450	Manufacturing
Bessant 2008	Empirical - case studies	Innovation management	Firm	N = 25	Not specified
Bonesso et al. 2011	Empirical - statistical sampling	Innovation management	Project	N = 60	Manufacturing
Britton 2004	Empirical - statistical sampling	Innovation management	Firm	N = 61	Manufacturing
Caner and Tyler 2015	Empirical - statistical sampling	Innovation management	Firm	N = 143	Health Care
Cantwell and Zhang 2013	Empirical - statistical sampling	Innovation management	Firm	N = 554 patents	Multiple
Capaldo and Messini Petruzzelli 2015	Empirical - statistical sampling	Innovation management	Firm	N = 1,515	Manufacturing
Chandler and Hwang 2015	Analytical - conceptual	Innovation management	Firm	-	-
Chen et al. 2011	Empirical - statistical sampling	Innovation management	Firm	N = 209	Multiple
Chiang and Hung 2010	Empirical - statistical sampling	Innovation management	Firm	N = 220	Manufacturing
Cho et al. 2011	Empirical - statistical sampling	Innovation management	Firm	N = 825	Services
Clausen et al. 2013	Empirical - statistical sampling	Innovation management	Firm	N = 1,199	Multiple
Cruz-González et al. 2014	Empirical - statistical sampling	Innovation management	Firm	N = 248	Manufacturing

Publication	Research method	Research area	Level of analysis	Sample size	Industry
Cruz-González et al. 2015a	Empirical - statistical sampling	Innovation management	Firm	N = 248	Manufacturing
Cruz-González et al. 2015b	Empirical - statistical sampling	Innovation management	Firm	N = 248	Manufacturing
Dahlander et al. 2014	Empirical - statistical sampling	Innovation management	Individual	N = 615	Information Technology
Datta and Jessup 2013	Empirical - statistical sampling	Innovation management	Firm	N = 192,070 patents	Information Technology
Dawes et al. 2007	Empirical - statistical sampling	Corporate decision making and problem solving	Firm	N = 102	Multiple
De Araujo Burcharth et al. 2015	Empirical - statistical sampling	Innovation management	Firm	N = 169	Manufacturing
Ebersberger and Herstad 2011	Empirical - statistical sampling	Innovation management	Firm	N = 1,540	Multiple
Egbetokun 2015	Empirical - statistical sampling	Innovation management	Firm	N = 472	Manufacturing
Erat and Krishnan 2012	Analytical - mathematical research	Innovation management	Firm	-	-
Felin and Zenger 2014	Analytical - mathematical research	Innovation management	Firm	-	-
Feng et al. 2014	Empirical - statistical sampling	Innovation management	Firm	N = 176	Manufacturing
Ferreras-Méndez et al. 2015	Empirical - statistical sampling	Innovation management	Firm	N = 102	Health Care
Fixson and Lee 2012	Empirical - statistical sampling	Innovation management	Firm	N = 17	Manufacturing
Fontana et al. 2006	Empirical - statistical sampling	Innovation management	Firm	N = 558	Multiple
Fosfuri and Tribó 2008	Empirical - statistical sampling	Innovation management	Firm	N = 2,464	Multiple
Gallego et al. 2013a	Empirical - statistical sampling	Innovation management	Firm	N = 170	Multiple
Gallego et al. 2013b	Empirical - statistical sampling	Innovation management	Firm	N = 260	Multiple
García-Granero et al. 2014	Empirical - statistical sampling	Innovation management	Firm	N = 101	Manufacturing
Garriga et al. 2013	Empirical - statistical sampling	Innovation management	Firm	N = 2,141	Multiple
Gruber et al. 2013	Empirical - statistical sampling	Innovation management	Individual	N = 496	Multiple
Guo 2009	Empirical - statistical sampling	Innovation management	Individual	N = 282	Multiple
Guo and Wang 2014	Empirical - statistical sampling	Innovation management	Firm	N = 491	Manufacturing
Guo et al. 2015	Empirical - statistical sampling	Innovation management	Firm	N = 491	Manufacturing
Henttonen and Ritala 2013	Empirical - statistical sampling	Innovation management	Firm	N = 193	Multiple

Publication	Research method	Research area	Level of analysis	Sample size	Industry
Henttonen et al. 2011	Empirical - statistical sampling	Innovation management	Firm	N = 193	Multiple
Holmes and Smart 2009	Empirical - case studies	Innovation management	Firm	N = 8	Multiple
Horváth and Enkel 2014	Empirical - case studies	Innovation management	Project	N = 8	Manufacturing
Huang et al. 2015	Empirical - statistical sampling	Innovation management	Firm	Not specified	Multiple
Jeppesen and Lakhani 2010	Empirical - statistical sampling	Innovation management	Individual	N = 166	Multiple
Jiang et al. 2010	Empirical - statistical sampling	Innovation management	Firm	N = 68	Manufacturing
Katila and Ahuja 2002	Empirical - statistical sampling	Innovation management	Firm	N = 124	Manufacturing
Keinz and Prügl 2010	Empirical - case studies	Innovation management	Firm	N = 1	Manufacturing
Kim and Park 2013	Empirical - statistical sampling	Innovation management	Firm	N = 89	Health Care
King and Lekse 2006	Empirical - statistical sampling	Corporate decision making and problem solving	Individual	N = 97	Not specified
Köhler et al. 2012	Empirical - statistical sampling	Innovation management	Firm	N = 4,933	Multiple
Laursen 2011	Empirical - statistical sampling	Innovation management	Firm	N = 3,418	Multiple
Laursen 2012	Analytical - conceptual	Innovation management	Firm	-	-
Laursen and Salter 2004	Empirical - statistical sampling	Innovation management	Firm	N = 2,655	Manufacturing
Laursen and Salter 2006	Empirical - statistical sampling	Innovation management	Firm	N = 2,707	Manufacturing
Laursen and Salter 2014	Empirical - statistical sampling	Innovation management	Firm	N = 2,931	Manufacturing
Laursen et al. 2010	Empirical - statistical sampling	Innovation management	Firm	N = 176	Multiple
Lazzarotti and Pellegrini 2015	Empirical - statistical sampling	Innovation management	Firm	N = 182	Manufacturing
Lee et al. 2011	Empirical - statistical sampling	Innovation management	Firm	N = 178	Multiple
Lee et al. 2015	Empirical - statistical sampling	Innovation management	Firm	N = 29	Information Technology
Leiponen 2012	Empirical - statistical sampling	Innovation management	Firm	N = 121	Manufacturing
Liu et al. 2013	Empirical - statistical sampling	Innovation management	Firm	N = 141	Multiple
Li-Ying et al. 2014	Empirical - statistical sampling	Innovation management	Firm	N = 178	Multiple
Lopez-Vega et al. 2016	Empirical - case studies	Innovation management	Firm	N = 34	Multiple
Love et al. 2014	Empirical - statistical sampling	Innovation management	Firm	N = 1,064	Manufacturing

Publication	Research method	Research area	Level of analysis	Sample size	Industry
Martinez et al. 2014	Empirical - statistical sampling	Innovation management	Firm	N = 284	Manufacturing
Miller et al. 2007	Empirical - statistical sampling	Innovation management	Firm	N = 211,636 patents	Multiple
Mina et al. 2014	Empirical - statistical sampling	Innovation management	Firm	N = 819	Multiple
Mol and Birkinshaw 2009	Empirical - statistical sampling	Innovation management	Firm	N = 3,668	Multiple
Morris et al. 2014	Empirical - statistical sampling	Corporate decision making and problem solving	Project	N = 97	Services
Mortara et al. 2010	Empirical - case studies	Innovation management	Firm	N = 1	Manufacturing
Natalicchio et al. 2014	Analytical - conceptual	Innovation management	Firm	-	-
Noseleit and De Faria 2013	Empirical - statistical sampling	Innovation management	Firm	N = 60	Manufacturing
Nosella 2014	Empirical - statistical sampling	Innovation management	Firm	N = 88	Multiple
Paananen 2009	Empirical - statistical sampling	Innovation management	Firm	N = 804	Multiple
Paananen 2012	Empirical - statistical sampling	Innovation management	Firm	N = 804	Multiple
Park et al. 2014	Empirical - case studies	Innovation management	Individual	N = 1	Manufacturing
Piezunka and Dahlander 2015	Empirical - statistical sampling	Innovation management	Firm	N = 105,127 suggestions	Multiple
Pineda et al. 1998	Empirical - statistical sampling	Corporate decision making and problem solving	Individual	N = 131	Multiple
Poetz and Prügl 2010	Empirical - case studies	Innovation management	Individual	N = 1,147	Multiple
Ren et al. 2015	Empirical - statistical sampling	Innovation management	Firm	N = 176	Multiple
Ritala et al. 2013	Empirical - statistical sampling	Innovation management	Firm	N = 193	Multiple
Roper and Hewitt-Dundas 2015	Empirical - statistical sampling	Innovation management	Firm	N = 2,085	Manufacturing
Rosenkopf and Almeida 2003	Empirical - statistical sampling	Innovation management	Firm	N = 995 patents	Manufacturing
Rosenkopf and Nerkar 2001	Empirical - statistical sampling	Innovation management	Firm	N = 2,333 patents	Manufacturing
Saebi and Foss 2015	Analytical - conceptual	Innovation management	Firm	-	-
Salge et al. 2013	Empirical - statistical sampling	Innovation management	Project	N = 62	Health Care
Salter et al. 2015	Empirical - statistical sampling	Innovation management	Individual	N = 329	Not specified
Sofka and Grimpe 2010	Empirical - statistical sampling	Innovation management	Firm	N = 5,082	Multiple
Spithoven et al. 2013	Empirical - statistical sampling	Innovation management	Firm	N = 967	Multiple

Publication	Research method	Research area	Level of analysis	Sample size	Industry
Srivastava et al. 2015	Empirical - statistical sampling	Innovation management	Firm	N = 178	Manufacturing
Stockstrom et al. 2016	Empirical - statistical sampling	Innovation management	Individual	N = 942	Education
Vahter et al. 2014	Empirical - statistical sampling	Innovation management	Firm	Not specified	Manufacturing
Vasudeva and Anand 2011	Empirical - statistical sampling	Innovation management	Firm	N = 138	Manufacturing
Wagner et al. 2014	Empirical - statistical sampling	Innovation management	Firm	N = 98,612 patents	Services
Wang et al. 2014	Empirical - statistical sampling	Innovation management	Firm	N = 279	Multiple
Wu 2013	Empirical - statistical sampling	Innovation management	Firm	N = 1,262	Multiple
Wu and Wu 2014	Empirical - statistical sampling	Innovation management	Firm	N = 343	Manufacturing
Wu et al. 2013	Empirical - statistical sampling	Innovation management	Firm	N = 393	Multiple
Zang et al. 2014	Empirical - statistical sampling	Innovation management	Firm	N = 162	Multiple
Zhang and Li 2010	Empirical - statistical sampling	Innovation management	Firm	N = 202	Manufacturing

Table 7: Overview classification core publications – search focus and search dimensions

		Search scope			Search distance			
Publication	Search focus	Breadth	Depth	Direction	Technological	Geographical	Temporal	Relational
Adebe 2012	Environmental discontinuities	x						
Afuah and Tucci 2012	Problem solutions							
Alguezaui and Filieri 2010	Innovation							
Almirall and Casadesus-Masanell 2010	Innovation							
Ammetller et al. 2014	Decision support	x						
Argyres and Silverman 2004	Innovation	x			x			
Azagra-Caro et al. 2014	Innovation	x						
Bauer and Gegenhuber 2015	Problem solutions							
Belussi et al. 2010	Innovation	x				x		
Bennett 2005	Environmental discontinuities	x	x					

		Search scope			Search distance			
Publication	**Search focus**	**Breadth**	**Depth**	**Direction**	**Technological**	**Geographical**	**Temporal**	**Relational**
Bergendahl and Magnusson 2015	Innovation		x					
Bessant 2008	Environmental discontinuities							
Bonesso et al. 2011	Innovation		x					
Britton 2004	Innovation	x				x		
Caner and Tyler 2015	Innovation		x					
Cantwell and Zhang 2013	Innovation				x	x	x	
Capaldo and Messini Petruzzelli 2015	Innovation				x	x		
Chandler and Hwang 2015	Innovation							
Chen et al. 2011	Innovation	x	x	x				
Chiang and Hung 2010	Innovation	x	x					
Cho et al. 2011	Innovation	x						
Clausen et al. 2013	Innovation			x				
Cruz-González et al. 2014	Innovation	x						
Cruz-González et al. 2015a	Innovation	x						
Cruz-González et al. 2015b	Innovation	x	x					
Dahlander et al. 2014	Innovation	x	x					
Datta and Jessup 2013	Innovation		x					
Dawes et al. 2007	Decision support		x					
De Araujo Burcharth et al. 2015	Innovation	x						
Ebersberger and Herstad 2011	Innovation	x						
Egbetokun 2015	Innovation	x						
Erat and Krishnan 2012	Problem solutions							
Felin and Zenger 2014	Problem solutions							
Feng et al. 2014	Innovation		x					
Ferreras-Méndez et al. 2015	Innovation	x	x					
Fixson and Lee 2012	Innovation			x	x			

		Search scope			Search distance			
Publication	**Search focus**	**Breadth**	**Depth**	**Direction**	**Technological**	**Geographical**	**Temporal**	**Relational**
Fontana et al. 2006	Innovation	x						
Fosfuri and Tribó 2008	Innovation		x					
Gallego et al. 2013a	Innovation	x						
Gallego et al. 2013b	Innovation		x					
García-Granero et al. 2014	Innovation			x				
Garriga et al. 2013	Innovation	x	x					
Gruber et al. 2013	Market opportunities	x						
Guo 2009	Innovation		x					
Guo and Wang 2014	Innovation	x						
Guo et al. 2015	Innovation	x	x					
Henttonen and Ritala 2013	Innovation	x						
Henttonen et al. 2011	Innovation	x						
Holmes and Smart 2009	Innovation							
Horváth and Enkel 2014	Innovation	x	x	x				
Huang et al. 2015	Innovation	x	x		x			
Jeppesen and Lakhani 2010	Problem solutions				x			x
Jiang et al. 2010	Innovation				x			
Katila and Ahuja 2002	Innovation		x	x				
Keinz and Prügl 2010	Market opportunities				x			
Kim and Park 2013	Innovation			x	x			
King and Lekse 2006	Problem solutions							x
Köhler et al. 2012	Innovation	x						
Laursen 2011	Innovation	x				x		
Laursen 2012	Innovation							
Laursen and Salter 2004	Innovation	x						
Laursen and Salter 2006	Innovation	x	x					

		Search scope			Search distance			
Publication	**Search focus**	**Breadth**	**Depth**	**Direction**	**Technological**	**Geographical**	**Temporal**	**Relational**
Laursen and Salter 2014	Innovation	x						
Laursen et al. 2010	Innovation	x		x	x			
Lazzarotti and Pellegrini 2015	Innovation	x						
Lee et al. 2011	Innovation		x			x		
Lee et al. 2015	Innovation		x					
Leiponen 2012	Innovation	x						
Liu et al. 2013	Environmental discontinuities	x	x					
Li-Ying et al. 2014	Innovation				x	x	x	
Lopez-Vega et al. 2016	Problem solutions							
Love et al. 2014	Innovation	x						
Martinez et al. 2014	Innovation	x	x					
Miller et al. 2007	Innovation				x			
Mina et al. 2014	Innovation		x					
Mol and Birkinshaw 2009	Innovation	x						
Morris et al. 2014	Problem solutions		x					
Mortara et al. 2010	Innovation							
Natalicchio et al. 2014	Innovation							
Noseleit and De Faria 2013	Innovation		x		x			
Nosella 2014	Innovation		x					
Paananen 2009	Innovation	x						
Paananen 2012	Innovation	x						
Park et al. 2014	Innovation							
Piezunka and Dahlander 2015	Innovation				x			x
Pineda et al. 1998	Decision support		x					
Poetz and Prügl 2010	Innovation							
Ren et al. 2015	Innovation	x						

		Search scope			Search distance			
Publication	**Search focus**	**Breadth**	**Depth**	**Direction**	**Technological**	**Geographical**	**Temporal**	**Relational**
Ritala et al. 2013	Innovation	x						
Roper and Hewitt-Dundas 2015	Innovation	x						
Rosenkopf and Almeida 2003	Innovation				x	x		
Rosenkopf and Nerkar 2001	Innovation			x	x			
Saebi and Foss 2015	Innovation							
Salge et al. 2013	Innovation	x						
Salter et al. 2015	Innovation		x					
Sofka and Grimpe 2010	Innovation	x						
Spithoven et al. 2013	Innovation	x						
Srivastava et al. 2015	Innovation		x					
Stockstrom et al. 2016	Innovation							
Vahter et al. 2014	Innovation	x						
Vasudeva and Anand 2011	Innovation		x		x			
Wagner et al. 2014	Innovation				x	x		
Wang et al. 2014	Innovation		x					
Wu 2013	Innovation	x						
Wu and Wu 2014	Innovation					x		
Wu et al. 2013	Innovation		x					
Zang et al. 2014	Innovation	x	x					
Zhang and Li 2010	Innovation		x					

Table 8: Overview of clusters and publications (own analysis)

No.	Cluster	Publications
1	Organizational search and open innovation	Chesbrough 2003
		Cohen and Levinthal 1990
		Dahlander and Gann 2010
		Fleming and Sorenson 2004
		Katila and Ahuja 2002
		Kogut and Zander 1992
		Laursen and Salter 2006
		Leiponen and Helfat 2010
		March 1991
		Martin and Mitchell 1998
		Nelson and Winter 1982
		Rosenkopf and Nerkar 2001
		Stuart and Podolny 1996
		Von Hippel 1988
2	External knowledge and innovation	Chen et al. 2011
		De Luca and Atuahene-Gima 2007
		Escribano et al. 2009
		Hung and Chou 2013
		Köhler et al. 2012
		Leiponen and Helfat 2011
		Lichtenthaler et al. 2011
		Murovec and Prodan 2009
		Nieto and Santamaria 2007
		Oerlemans et al. 2013
		Sisodiya et al. 2013
		Todorova and Durisin 2007
		Tödtling et al. 2009
		Tsai and Wang 2009
		Voudouris et al. 2012
		Wang and Hsu 2014
		Yu 2013
		Zahra and Bogner 2000
3	User innovation	Franke et al. 2006
		Lilien et al. 2002
		Von Hippel et al. 1999
		Von Hippel et al. 2009
4	Broadcast search	Afuah and Tucci 2012
		Boudreau et al. 2011
		Howells 2006
		Jeppesen and Lakhani 2010
		Verona et al. 2006
5	Solution search and innovation contests	Che and Gale 2003
		Kauffman 1993
		Levinthal 1997
		Simon 1969

No.	Cluster	Publications
		Taylor 1995
		Terwiesch and Xu 2008
6	Knowledge sourcing strategies	Kang and Kang 2009
		Galunic and Rodan 1998
		Ritala and Hurmelinna-Laukkanen 2009
		Sofka and Grimpe 2010
7	External orientation and entrepreneurship	Covin and Slevin 1989
		Day 1994
		Lee et al. 2001
		Stam and Elfring 2008
8	Interfirm knowledge transfer	Almeida and Kogut 1999
		Mowery et al. 1996
		Saxenian 1990
		Zander and Kogut 1995
9	Knowledge spillovers from academic research	Acs et al. 1994
		Arundel and Geuna 2004
		Mansfield 1991
		Mohnen and Hoareau 2003
10	Complementarities in innovation	Bayona et al. 2001
		Fritsch and Lukas 2001
		Milgrom and Roberts 1990
		Mohnen and Röller 2005
		Veugelers 1997
11	Absorptive capacity	Fosfuri and Tribó 2008
		Jansen et al. 2005
		Lane et al. 2006
		Van den Bosch et al. 1999
		Vega-Jurado et al. 2008
12	Knowledge transfer and protection	Liebeskind 1996
		Nelson 1991
		Polanyi 1966
		Williamson 1985
13	Social networks	Brown and Duguid 1991
		Burt 2004
		Coleman 1990
		Granovetter 1973
		Hansen 1999
		Hargadon and Sutton 1997
		Nahapiet and Ghoshal 1998
		Obstfeld 2005
14	Innovation and productivity	Crépon et al. 1998
		Freel 2005
		Griliches 1995
		Roper et al. 2008