



# Reviewing the Field of External Knowledge Search for Innovation: Theoretical Underpinnings and Future (Re-)search Directions\*

Daniel Ehls , Sara Polier, and Cornelius Herstatt

*The field of external knowledge search for innovation has a long tradition and has inspired several schools of thought resulting in a rich and burgeoning body of research. However, the field suffers from two key limitations. First, the pluralism of research across multiple disciplines impedes our attention to the field as a whole, including its intellectual structure and core ideas. Second, recent developments in the business environment and key new ideas in the field complement taken-for-granted approaches and provide new opportunities for knowledge search. Based on a systematic co-citation analysis, we provide a reflective review of the literature and make several contributions. We integrate existing research across disciplines and offer a synthesis of a fragmented research landscape to present a global view of the field. Moreover, we propose a novel external search concept and introduce the idea of “decoupled search.” Leveraging our synthesis and conceptualization further, we recommend future research directions for the entire field of external knowledge search for innovation.*

## Practitioner Points

- This article systematically integrates existing research across several disciplines and offers a synthesis of the field of external knowledge search for innovation.
- By providing a framework that highlights the evolution of the field in phases, firms can better align their approaches for conducting external knowledge search.
- By introducing the decoupled search approach, executives are challenged to rethink their external search efforts and to better orchestrate the interface with external (unbounded) contributors for leveraging new promising opportunities.

Address correspondence to: Daniel Ehls, Hamburg University of Technology, Am Schwarzenberg-Campus 4, 21073 Hamburg, Germany. E-mail: daniel.ehls@tuhh.de

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## Introduction

Innovations are central to organizational performance due to their potential for creating competitive advantage, customer satisfaction, and value creation (Cohen and Levinthal, 1990). A longstanding model of innovation creation is the concept of knowledge recombination (Fleming, 2001; March, 1991; Schumpeter, 1934). Organizations leverage their available knowledge base and mix specific knowledge elements to create useful and novel combinations (Grant, 1996; Kogut and Zander, 1992). Accordingly, the search for new knowledge elements to increase the available knowledge base is essential for organizations and innovation generation (March, 1991).

While organizations can increase their knowledge base by local search within their organizational boundaries, several studies document the power of external search, understood as all organizational activities that involve the creation and recombination of knowledge from a wide range of external sources outside the boundaries of the firm, such as customers, suppliers, competitors, and universities (Katila and Ahuja, 2002; Laursen and Salter, 2006, 2014). For example, Cohen, Nelson, and Walsh (2002) show that leveraging knowledge sources beyond organizations' own R&D laboratories is of the highest importance. Searching more distant and uncharted territory compared to the existing knowledge base results in an increased rate of new product development (Katila,

2002), improved product quality in organizations' more novel developments (Eggers, Baker, Gonzalez, and Vaughn, 2012), greater success in problem solving (Jeppesen and Lakhani, 2010), and a higher likelihood of breakthrough innovations (Ahuja and Lampert, 2001; Chai, 2017; Rosenkopf and Nerkar, 2001) at unprecedented speed (Lifshitz-Assaf, 2018).

Given the high relevance of this topic, it is not surprising that numerous researchers across disciplines, such as innovation management, strategy, and organization science, have contributed to this flourishing field of external knowledge seeking for innovation. However, the field suffers from two key challenges. First, the pluralism of research across multiple disciplines and their literature streams—including, for example, studies on open innovation, crowdsourcing, user innovation, knowledge management, alliances, and university–industry collaboration—impedes our attention to the field as a whole and to its intellectual

structure and core ideas in particular. There is not only a lack of a joint understanding, constituting clusters, and theoretical underpinnings for external knowledge search for innovation but also a threat of encapsulation. However, bridging knowledge across disciplines is particularly fruitful for advancing our theoretical understanding and yielding novel insights (Chai, 2017; Zahra and Newey, 2009).

The second challenge arises from recent developments in the business environment and the emergence of key new ideas in the field altering the way organizations search externally for knowledge. Taken-for-granted methods for external knowledge search for innovation are, today, complemented by newer approaches. For instance, until the last decade collaborations were mainly commercial and transactional processes, such as in interorganizational alliances or university collaborations; today, however, the availability of computer-mediated networks enables leveraging the knowledge of distributed single minds, such as in broadcast search or in firm-hosted communities. These latest approaches are less formal and rarely include price negotiations. Moreover they require a new way of thinking in order to take advantage of the tremendous increase of the knowledge base.

Taking both challenges together, the richness and dynamism of research potentially hinders the development of a coherent body of knowledge, with the result that a comprehensive understanding of the field is lacking. Accordingly, researchers have called for action to address this fragmented theoretical understanding (Grimpe and Sofka, 2016) in order to improve the search for external knowledge for innovations (Criscuolo, Laursen, Reichstein, and Salter, 2018).

Despite the importance of external knowledge search for innovation, as yet there has been neither a systematic review nor a synthesis of the field, making it difficult to follow the scholarship and identify core concepts. Some recent reviews have focused on specific facets of external knowledge search for innovation, such as knowledge integration (Zahra, Neubaum, and Hayton, 2020), problemistic search (Posen, Keil, and Meissner, 2018), and implemented search solutions (Savino, Messeni Petruzzelli, and Albino, 2017). Although very valuable, these studies, by being limited to their particular perspective, do not take a larger view across the field for an integrative understanding. Moreover, they miss to make a systematic connection of relevant research streams that is important for knowledge synthesis (Torraco, 2005).

#### BIOGRAPHICAL SKETCHES

**Dr. Daniel Ehls** is a habilitation student at Hamburg University of Technology and a postdoctoral researcher at the Helmut Schmidt University Hamburg. His main areas of expertise are distributed problem solving and innovation management in relation to leveraging the opportunities of a digitized economy. He conducted research at Tokyo Tech University and holds a visiting appointment at the Laboratory for Innovation Science at Harvard University. He has edited the book (together with Prof. Cornelius Herstatt) *Open Source Innovation: The Phenomenon, Participant's Behavior, Business Implication*. Prior to his academic career, he worked as a management consultant and he continues to pursue projects with managerial impact.

**Dr. Sara Polier** has recently completed her Ph.D. in technology and innovation management at Hamburg University of Technology. Her research interests lie at the intersection of open innovation, organizational search behavior, and corporate foresight. In particular, she focuses on forward-looking external search as a driver for innovation. Complementing her academic work, she is a management consultant with a specific focus on projects in the area of digitization and IT in industries such as telecommunications, healthcare, and the public sector.

**Prof. Dr. Cornelius Herstatt** is head of the Institute for Technology and Innovation Management at Hamburg University of Technology (TUHH). His research and teaching interests include the management of innovation processes, user innovation, and frugal innovation. Prior to his appointment at TUHH, he held leading positions in industry and consulting. Prof. Herstatt has led and successfully implemented many innovation projects with industry. He has more than 300 publications on technology and innovation management, is active on numerous international committees, and is an editor for leading scientific journals. Prof. Herstatt has been a visiting professor at renowned universities in the United States, Australia, and Japan. He is a fellow of the JSPS (Japanese Society for Promoting Science), a research fellow of the East-West Center (Hawaii), and alumnus of Templeton College in Oxford.

Responding to these research gaps and calls to action, we aim to illuminate and integrate the pluralism of research in the field of external knowledge search for innovation. Our objective is not only to support scholars in navigating a multidisciplinary research landscape, but also to identify core themes for a better understanding and cross-fertilization of research in the field as well as to highlight promising future research opportunities to advance the field.

Our research makes two key contributions. First, we advance our theoretical and empirical knowledge by providing a reflective interpretation of the field of external knowledge search for innovation. A reflective review goes beyond an integrative review by additionally generating a novel concept (Post, Sarala, Gatrell, and Prescott, 2020; Rousseau, Manning, and Denyer, 2008). Our integrative work systematically analyzes and comprehensively synthesizes the field (Torraco, 2005). By clarifying the rich intellectual structure and linking existing research across disciplines, we reveal the core thematic clusters of the field, contrast the different thinking of search approaches in each phase, and provide a unified and cohesive “global view” of the field. This leads to a new ways of seeing for theory integration across disciplines (Shaw, Tangirala, Vissa, and Rodell, 2008) and responds to the call from *JPIM* to form stronger linkages between neighboring disciplines and to include the larger management literature on innovation (Sarin, Haon, and Belkhouja, 2018). Building on that, our generative work creates a new concept (Torraco, 2005) by developing the unique idea of “decoupled search.” We introduce an original model for managing external knowledge search for innovation (Gatrell and Breslin, 2017). Additionally, and based on our reflective review, our second key contribution is the development of a detailed research agenda. We provide novel opportunities to improve our theoretical understanding and pave the way for impactful interdisciplinary research.

## Conceptual Background

The knowledge-based view (KBV) prominently highlights the importance of the knowledge base for innovation and organizational success (Grant, 1996; Kogut and Zander, 1992). A key function of an organization is to integrate new knowledge (Grant, 1996), and some researchers even consider a firm to be “a social community specializing in the speed and transfer of knowledge” (Kogut and Zander, 1996,

p. 503). Notably, most of a firm’s knowledge is heterogeneously distributed among its members, thus residing at an individual level and being nested within the firm (Felin and Hesterly, 2007). This has important consequences. On one hand, organizational routines, including organizational structures, rules, and language, are important for successful knowledge transfer (Grant, 1996). On the other hand, individual behavior, including human shortcomings like bounded rationality, limited attention, and selection bias (March and Simon, 1958; Ocasio, 1997; Piezunka and Dahlander, 2015), impact knowledge transfer.

Routines and individual behavior are central in the behavioral theory of the firm, which also highlights search processes (Cyert and March, 1963; Nelson and Winter, 1982) and describes organizations as coalitions of individuals and groups whose decisions are determined by behavioral routines (Argote and Greve, 2007). In order to improve performance or adapt to a changing environment, organizations search for alternatives that may deviate from their existing routines in order to avoid path dependency (Levinthal and March, 1981; Levitt and March, 1988; Nelson and Winter, 1982). Accordingly, organizational search can be broadly understood as encompassing all activities “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). More recently, Li, Maggitti, Smith, Tesluk, and Katila (2013, p. 893) defined search as “the controlled and proactive process of attending to, examining, and evaluating new knowledge and information.” Therefore, identification of new knowledge is key to deviation from established routines and the creation of innovations.

The latent idea underpinning the knowledge-based view is our understanding of innovation as a recombination activity (Fleming, 2001; Kogut and Zander, 1992; March, 1991; Nelson and Winter, 1982). This idea dates back to the definition of innovation as “combining (of) materials and forces differently” (Schumpeter, 1934, p. 65). In order to combine knowledge in new ways, it is important for firms to increase their knowledge base as opportunities for identifying viable solutions increase with larger knowledge pools. Again, this maps onto the understanding of innovation as the outcome of organizational search (Galunic and Rodan, 1998; Greve, 2003b; Levinthal and March, 1993; March, 1991) and of searching for innovation as

“an organization’s problem-solving activities that involve the creation and recombination of technological ideas” (Katila and Ahuja, 2002, p. 1184).

A key distinction relating to the search for new knowledge for innovation and increasing a firm’s knowledge base is whether search activities are directed toward the firm’s internal or external knowledge sources. While internal search aims at knowledge residing inside the focal firm, external search is understood as all organizational activities that involve the creation and recombination of knowledge from a wide range of external sources outside the boundaries of the firm, such as customers, suppliers, competitors, and universities (Katila and Ahuja, 2002; Laursen and Salter, 2006, 2014). Hence, external search facilitates the traversing of organizational boundaries to explore more distant and unfamiliar territory. This knowledge transfer is frequently a process of brokerage across structural holes and between heterogeneous domains of knowledge (Burt, 2004; Jeppesen and Lakhani, 2010). Common knowledge in one domain might represent marginal, but much sought after, knowledge in another domain.

Consequently, the expectation of external knowledge search for innovation is not only to find novel and valuable knowledge pieces but also to avoid competency traps and core rigidity (Levitt and March, 1988; Rosenkopf and Nerkar, 2001). Several studies support this prospect and report increased rates of new product development (Katila, 2002), improved product quality in organizations’ new developments (Eggers et al., 2012), greater success in problem solving (Jeppesen and Lakhani, 2010), and higher likelihood of detecting breakthrough innovations (Ahuja and Lampert, 2001; Chai, 2017; Rosenkopf and Nerkar, 2001) at unprecedented speed (Lifshitz-Assaf, 2018). Some authors even claim that leveraging knowledge sources beyond organizations’ own R&D laboratories is of the utmost importance (Cohen et al., 2002). Given this importance, we aim to systematically take stock of the multidisciplinary field, identify its intellectual structure, and bring greater coherence to its research.

## Methodology

### *Research Approach and Data Collection*

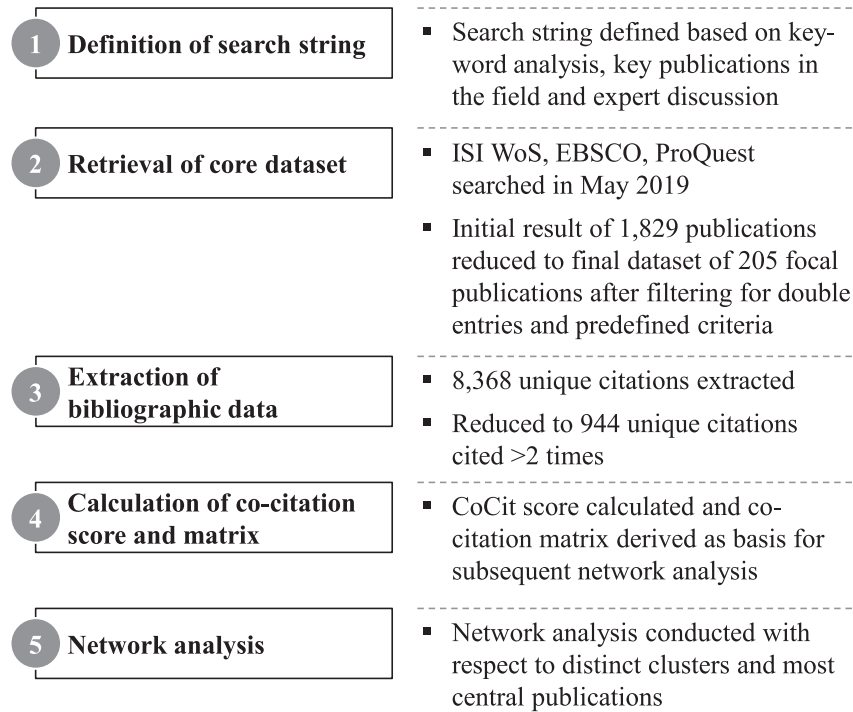
To uncover the intellectual structure of a research field, determine subject similarity, and discover relationships among research disciplines, the literature suggests co-citation analysis based on bibliographic citations as

a valid indicator (Garfield, 1979; Gmür, 2003; Small, 1973). Following earlier recommendations, we chose a document-based approach as the co-citation unit of analysis, since documents constitute the most valid and reliable indicator for the underlying structure of a research field (Chen, Ibekwe-SanJuan, and Hou, 2010; Small, 1973). Moreover, in applying a co-citation analysis based on the derived focal articles, we identified similar articles that are important for innovation management, even though their keywords were not included in our search string. We pursued a 5-step approach to derive the co-citation network (Figure 1).

Following prior reviews on multidisciplinary fields (Cankurtaran, Langerak, and Griffin, 2013; Hopp, Antons, Kaminski, and Salge, 2018), we relied on several keywords to cover the heterogeneous terminology in the field. To avoid the fallacy of following the path of popular terms, we derived our search string based on two approaches: twofold keyword analysis and expert discussion. Our first keyword analysis centered on our research subject area: external knowledge search for innovation, understood as all organizational activities that involve the creation and recombination of knowledge from a wide range of external sources outside the boundaries of the firm, such as customers, suppliers, competitors, and universities. This yields closely aligned keywords, namely “*external*,” “*outside*,” “*search*,” and “*knowledge*.” Second, we derived keywords from core publications in the field that clearly relate to innovation (namely, Afuah and Tucci, 2012; Jeppesen and Lakhani, 2010; Laursen and Salter, 2006).<sup>1</sup> To maintain a narrow focus, we examined the titles, abstracts, and keywords, which additionally gave us “*broadcast*,” “*open*,” and “*distant*.” However, we intentionally excluded popular search terms such as “open innovation” or “crowdsourcing,” as these represent strong fields of their own (see specific reviews, e.g., Randhawa, Wilden, and Hohberger, 2016) and their introduction would imply a strong bias.

Second, and beyond keyword analysis, we sought experts’ input. Reaching out to authors of our core

<sup>1</sup>Articles were selected on the basis of the high number of citations and a clear reference to external knowledge search for innovation visible in the abstract. For instance, Jeppesen and Lakhani (2010, p. 1060): “We also contribute to the knowledge-based theory of the firm by showing the effectiveness of a market mechanism to draw out knowledge from diverse external sources to solve internal problems”; Afuah and Tucci (2012, p. 355): “crowdsourcing transforms distant search into local search, improving the efficiency and effectiveness of problem solving”; Laursen and Salter (2006, p. 131): “A central part of the innovation process concerns the way firms go about organizing search for new ideas that have commercial potential.” Notably, Laursen and Salter’s (2006) article is a key study on open innovation, but it does not include the term itself. Applying the established term “open innovation” would not yield this article.



**Figure 1. Research Steps of Co-citation Analysis**

publications as well as to innovation management scholars familiar with the topic, we discussed our search query in order to ensure the validity, relevance, and completeness of the terms (Zupic and Cater, 2014). As a result, and to increase relevance, we changed the frequently applied term “knowledge” into the closely related terms “*information seeking*” and “*knowledge seeking*” in order to create suitable combinations of our keywords. We thus achieved a rather abstract search string to balance the trade-off of missing publications or results being driven in a specific direction, as well as to enable the discovery of related fields for innovation: (“*external*” OR “*distant*” OR “*outside*” OR “*open*” OR “*broadcast*”) AND (“*search*” OR “*information seeking*” OR “*knowledge seeking*”). Based on the search string, we collected our focal dataset of publications in May 2019 by searching in publication titles, keywords, and abstracts in the ISI Web of Science, EBSCO Business Source Premier, and ProQuest (Business) databases. After applying standard search filters,<sup>2</sup> we retrieved an initial dataset of 1829 publications (including 176 double entries due to our use of multiple databases).

<sup>2</sup>Standard filters: (1) language = English; (2) publication type = peer-reviewed academic articles, conference articles, book chapters, and books; and (3) research field = business- and management-related publications.

In our use of a broad search phrase and multiple overlapping databases, we followed prior reviews and minimized the risk of overlooking publications (Crossan and Apaydin, 2010; Dahlander and Gann, 2010; Randhawa et al., 2016). However, applying a broad search phrase is conducive to retrieving false positives, as it also captures publications containing the different search terms separately and outside our scope of organizational external knowledge search for innovation (e.g., “external search” as a term in consumer marketing). Therefore, two researchers independently reviewed all remaining 1653 publications with respect to given relevance criteria for false positive publications (Tranfield, Denyer, and Smart, 2003). Publications were excluded that (1) lack organizational context, such as those on information systems science and Internet search algorithms (e.g., Chen, Chau, and Zeng, 2002; Qian et al., 2002), as well as those on individual consumer search behavior for purchasing products (e.g., Lee and Cho, 2005); (2) lack explicit reference to knowledge search theory (e.g., generic use of the term “search,” as in Vömel, De Lorenzi, Beer, and Fuchs, [2015]); (3) focus on internal knowledge sources only, such as knowledge search within organizations (e.g., Petruzzelli and Rotolo, 2015); or (4) do not have a research focus, such as commentary essays

(e.g., Wu, 2010). This yielded our final dataset of 205 focal articles.

In applying additional post hoc validity checks—for example, by reviewing the articles in regards to aspects not determined by our search string but nevertheless relevant, like a high frequency of the word stem “innovat” or articles from management journals—we increased our confidence in our data and retained the focus on external knowledge search for innovation. Inter-coder reliability resulted in a level of agreement of 93.3%, indicating strong reliability and alignment with similar studies (Schilke, Hu, and Helfat, 2018).<sup>3</sup> Moreover, the ratio of selected articles to initially found articles is similar to that of recent reviews that have used multiple databases, broad search terms, and multiple exclusion steps (Posen et al., 2018) or is even lower than comparable reviews (Micheli, Wilner, Bhatti, Mura, and Beverland, 2019).<sup>4</sup>

In a third step, we extracted the bibliographic information (authors, title, publication year, and journal) for each citation from our data set to construct the co-citations matrix. We excluded methodological articles, as they tend to introduce bias by tying together portions of data (Garfield, 1979; Small, Sweeney, and Greenlee, 1985). After we standardized references and checked for identical articles under different names, the reference dataset consisted of 8368 unique citations. Following recommendations from the literature to set thresholds and include only publications that have been cited at least twice (Zupic and Cater, 2014), the final dataset contained 944 unique citations. We created a symmetrical matrix of absolute co-citations and calculated a co-citation score for each pair in the matrix. This score is considered superior to comparable measures, reduces the influence of citation relation by giving weight to both symmetrical and asymmetrical co-citation pairings, and shows a higher degree of robustness than the absolute co-citation count (Gmür, 2003). The resulting weighted co-citation matrix provided the input for the subsequent network analysis.

### *Centrality and Cluster Analysis*

To analyze the co-citation network, we utilized the network analysis software Organizational Risk Analyzer

<sup>3</sup>Differences in the review results were aligned based on an in-depth review and discussion between the researchers about the respective publications.

<sup>4</sup>Our study: 205/1653 = 12.40%; Posen et al. (2018): 233/2440 = 9.55%; Micheli et al. (2019): 104/32,232 = 0.32%.

(ORA), which has been used in previous studies (Santanello and Meyer, 2011), as it facilitates a comprehensive visual and statistical network structure evaluation (Carley, 2014). We analyzed the co-citation network based on three complementary methods for a more comprehensive view. First, we analyzed the most central publications and determined the local and global role of nodes based on the measures “total degree centrality,”<sup>5</sup> “closeness centrality,”<sup>6</sup> and “betweenness centrality”<sup>7</sup> (Freeman, 1978). Second, the entire network was analyzed with respect to its density, which indicates the general connectedness of the network through the extent to which its nodes are directly connected with one another (Otte and Rousseau, 2002). Third, and subsequently, we conducted a cluster analysis of the co-citation network to identify clusters in the research field. Following prior studies, to derive meaningful and unambiguous clusters, we set thresholds in the network that suppressed coincidental co-citations (Raasch et al., 2013) and excluded loosely connected publications (Small, 1980). In line with common practice (Babl, Schiereck, and Von Flotow, 2014; Meyer, Zaggli, and Carley, 2011), we evaluated the robustness of the network by gradually altering threshold levels for both link strength (L) and component size (C).<sup>8</sup> Our sensitivity analysis (Appendix 1) showed that the network structure is robust and that the selected thresholds of  $L > .45$  and  $C > 3$  allow for a good balance between size and number of individual clusters.

## **Results: The Field of External Knowledge Search**

### *Descriptive Results of Focal Articles*

Analysis of the distribution of the 205 focal publications across publication years (Figure 2) shows that the first of these publications date back to 1997. Triggered by the rise of the open innovation paradigm, attention started to increase from 2009 to 2010 and accelerated in 2013. About 70.7% of publications

<sup>5</sup>Defined as number of immediate ties of a node.

<sup>6</sup>Defined as total distance of a node from all other network nodes.

<sup>7</sup>Defined as frequency with which a node is found to be on the shortest link between any pair of nodes in the network.

<sup>8</sup>Link strength: strength of a relationship between any two publications, with high values indicating strong relationships (Di Guardo and Harrigan, 2012); Component size: number of connected publications in a cluster, with high values indicating large clusters (Liu, Bollen, Nelson, and Van De Sompel, 2005).

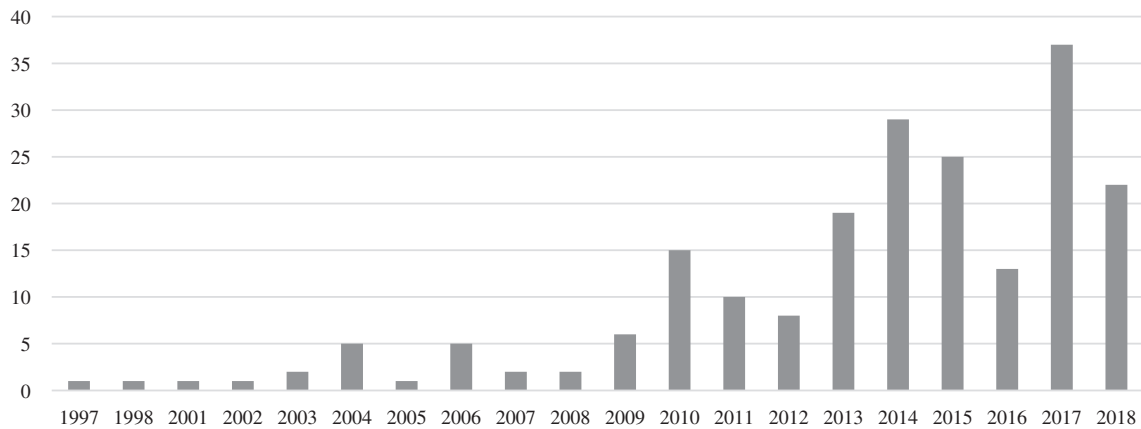


Figure 2. Number of Focal Articles on External Knowledge Search Per Year

Table 1. Journal Distribution of Focal Articles on External Knowledge Search

Journal	Publications	
	No.	%
<i>Research Policy</i>	16	7.8
<i>Technovation</i>	14	6.8
<i>Strategic Management Journal</i>	12	5.8
<i>Organization Science</i>	7	3.4
<i>Academy of Management Journal</i>	7	3.4
<i>Technology Analysis and Strategic Management</i>	6	2.9
<i>Industrial and Corporate Change</i>	6	2.9
<i>Technological Forecasting and Social Change</i>	6	2.9
<i>R&amp;D Management</i>	6	2.9
<i>International Journal of Innovation Management</i>	6	2.9
<i>Journal of Product Innovation Management</i>	6	2.9
<i>Industry and Innovation</i>	5	2.4
<i>Journal of Knowledge Management</i>	5	2.4
<i>Journal of Business Research</i>	5	2.4
Other	98	47.8
Total	205	100

Table 2. Top Keywords from Focal Articles on External Knowledge Search

Keyword	Frequency	
	Count	%
Open innovation	51	3.9
Innovation	48	3.6
Absorptive capacity	21	1.6
Innovation performance	17	1.3
Firm	16	1.2
Search	16	1.2
Knowledge	15	1.1
R&D	14	1.1
Openness	13	1.0
External search	13	1.0
External knowledge	11	.8
Patents	11	.8
Product innovation	10	.8
Search strategies	10	.8
New product development	9	.7
Exploration	9	.7
Breadth	8	.6
Boundary-spanning	8	.6
Knowledge sources	8	.6
Total keywords	1324	

in the analyzed dataset emerged between 2013 and 2018, highlighting the momentum of external knowledge search for innovation.

Scientific work in the realm of external search is published in 73 journals, but more than 51% of publications appear in the top 14 journals only (Table 1). Interestingly, of the top 14 journals, those with an innovation focus (such as *Research Policy*, *Technovation*, *R&D Management*, and *Journal of Product Innovation Management*) accounted for approximately 25% of all publications, which illustrates the multidisciplinary nature of the research field.

Table 2 shows the analysis of keyword frequencies in the focal articles. Again, innovation-related keywords (such as “open innovation,” “innovation,” and “innovation performance”) rank highest, followed by keywords relating to search behavior (“search,” “search strategies”) and the use of external sources (“external search,” “external knowledge,” “openness,” “exploration,” “boundary-spanning”). Interestingly, aspects relating to the foundations of the field, such as behavioral theory or organizational learning, are missing in the top-cited keywords. This may indicate that research on external knowledge

search seems to take little advantage of its sound theoretical basis.

Overall, the descriptive results point toward a strong focus of the research field on the innovation context, even though its roots are in organizational science and strategic management. This emphasizes the high relevance of the core data set for innovation research in general, and of the broad field of external knowledge search in particular, with its various domains beyond innovation management, such as strategy and organization science.

### *Intellectual Structure of the Research Field*

Identification of the theoretical foundations and structure of the research field involved three analyses: first, we characterized the overall network based on its density; second, we detected central and boundary-spanning publications; and third, we identified its intellectual clusters, including its relationships, and, thus, the core themes of external knowledge search.

*Network density.* The overall network has a total of 944 nodes and more than 160,000 links with a mean co-citation strength of .055. After applying the selected link threshold of  $L > .45$ , and component threshold of  $C > 3$ , the final network includes 68 nodes and 190 links with a mean co-citation strength of .663. This finding is substantial because, considering the density score as a measure of network cohesion (Otte and Rousseau, 2002), the initial network has a low score of .199, indicating a sparse network (De Nooy, Mrvar, and Batagelj, 2005). Moreover, the final network has an even lower density score of .042. While low network density may also be influenced by the overall network size (Raasch et al., 2013), it serves as an indicator of a general fragmentation of the research field, pointing toward the unutilized potential for cross-fertilization among its clusters.

*Network centrality.* In order to obtain insights into the structure of the network, the entire network without thresholds was taken as the basis for analysis of the centrality of individual publications. Table 3 shows the essential publications according to centrality measures.

Two key findings are obtained from the analysis. First, it reveals the most influential publications in the field. Second, it again shows the multidisciplinary of the field, with publications from innovation management, strategy, organization science, and general

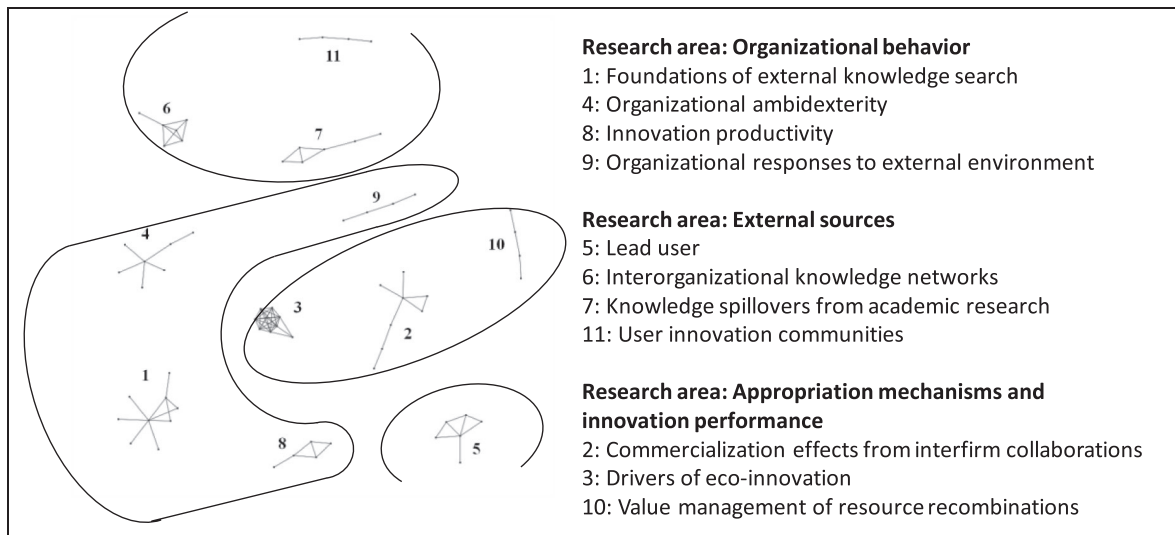
management. Taken together, these findings are even more powerful because, in order to understand the field as a whole and grasp all its theoretical underpinnings, it is not enough to concentrate on a single domain; rather, all related domains should be included in a global view. It is notable that Chesbrough (2003) is the only innovation management publication in the category of total degree centrality, indicating the overall number of links to other publications. However, within the category of closeness centrality, which indicates publications most close to other nodes, we find a comparatively high number of scholars publishing in innovation journals (Chesbrough and Crowther, 2006; Howells, 2006; Spithoven, Clarysse, and Knockaert, 2011; Un, Cuervo-Cazurra, and Asakawa, 2010). This points to a potentially strong integrative role of innovation management whereby it influences other domains rapidly. However, there is still some way to go before innovation management publications gain more attention, as we see from the category of betweenness centrality, which indicates bridges between nodes in a network. So far, only two innovation publications (Chesbrough, 2003; Un et al., 2010) have strongly influenced the flow to other domains.

The centrality analysis also reveals the most prominent theories leveraged in the field. Authors draw on absorptive capacity (Cohen and Levinthal, 1990; Spithoven et al., 2011; Zahra and George, 2002), the knowledge-based view (Kogut and Zander, 1992), and behavioral theory of the firm (Nelson and Winter, 1982) and its concept of organizational learning (Levinthal and March, 1993; March, 1991). From a content and domain perspective, several studies make a clear link to innovation management (Chesbrough, 2003; Chesbrough and Crowther, 2006; Howells, 2006, Laursen and Salter, 2006; Un et al., 2010) and to core external knowledge search concepts (Katila and Ahuja, 2002; Leiponen and Helfat, 2010; Rosenkopf and Nerkar, 2001). This supports the pivotal role of external knowledge search for organizational competitiveness and innovation creation, while also indicating a rich but fragmented multidomain research landscape.

*Network clusters.* Our next analysis shifted the view from individual articles to research clusters within the network in order to reveal distinctive research themes and publications of intellectual proximity. In line with prior findings of a fragmented field, our algorithm was able to clearly distinguish between 11 clusters resembling our network (Figure 3), thereby

**Table 3. Overview of the most central publications in the network**

Rank	Total Degree Centrality		Closeness Centrality		Betweenness Centrality	
	Publication	Value	Publication	Value	Publication	Value
1	Cohen and Levinthal (1990)	.052	Nelson and Winter (1982)	.091	Nelson and Winter (1982)	.203
2	Laursen and Salter (2006)	.044	Howells (2006)	.086	Katila and Ahuja (2002)	.164
3	Chesbrough (2003)	.039	Un et al. (2010)	.086	Leiponen and Helfat (2010)	.120
4	Rosenkopf and Nerkar (2001)	.039	Chesbrough and Crowther (2006)	.084	Laursen and Salter (2006)	.105
5	Katila and Ahuja (2002)	.036	Leiponen and Helfat (2010)	.084	March (1991)	.095
6	March (1991)	.034	Katila and Ahuja (2002)	.084	Chesbrough (2003)	.092
7	Nelson and Winter (1982)	.032	Spithoven et al. (2011)	.081	Un et al. (2010)	.082
8	Leiponen and Helfat (2010)	.031	Levinthal and March (1993)	.081	Rosenkopf and Nerkar (2001)	.070
9	Kogut and Zander (1992)	.028	March (1991)	.081	Kogut and Zander (1992)	.062
10	Zahra and George (2002)	.027	Jaffe, Trajtenberg, and Henderson (1993)	.081	Zahra and George (2002)	.062
	Network mean	.040	Network mean	.058	Network mean	.002



**Figure 3. Overview of the Co-citation Network ( $L > 0.45$ ,  $C > 3$ ) with Clusters and Research Areas**

confirming and further detailing the heterogeneity of the field. Although having a limited global view with few outside connections, each cluster is particularly robust and has a strong inward view, thus suggesting cohesive internal schools of thought. All clusters are detailed in Table 4 and, given space constraints, we focus here on the overall network effects. Based on the physical proximity between clusters in the network, and hence the closeness of the represented theoretical concepts, we derive three larger overarching research areas. This connectedness synthesis (and corroboration based on contextual investigation of each cluster’s articles) also indicates how each cluster contributes to a higher meaningfulness in the entire field.

While there is no clear center of gravity in the network with strong connections to all other clusters,

cluster 2 (commercialization effects from interfirm collaborations) and cluster 3 (drivers of eco-innovation) are the only two clusters completely surrounded by other clusters. They include the latest publications in the field. Financial considerations for eco- respectively open innovation settings are a central motion of both clusters. Cluster 10 (value management of resource recombinations) is closely aligned to network proximity and focuses on measurements and effects of resource recombination for innovation performance, as well as on financial aspects. Given the close proximity of these three clusters and their joint strong consideration of value-capture options, we interpret them as strongly related and as a research area that studies appropriation mechanisms and innovation performance.

**Table 4. Overview of Clusters in Co-citation Network**

Research Area	Cluster	Cluster Profile	Example Publications	Focus of Cluster
<i>Organizational behavior</i>	<i>Cluster 1: Foundations of external knowledge search</i>	<i>N = 9</i> Age span: 1982–2010	Cohen and Levinthal (1990), Laursen and Salter (2006), Rosenkopf and Nerkar (2001)	Theoretical foundations of external knowledge search relating to evolutionary theory, organizational learning, absorptive capacity, open innovation, and boundary-spanning
<i>Appropriation mechanisms and innovation performance</i>	<i>Cluster 2: Commercialization effects from interfirm collaborations</i>	<i>N = 7</i> Age span: 2010–2015	Belderbos, Faems, Leten, Van Looy, and Van Looy (2010), Faems, De Visser, Andries, and Van Looy (2010), Greco, Grimaldi, and Cricelli (2015)	Effects of interfirm collaboration on firm and innovation performance with respect to open innovation
<i>Appropriation mechanisms and innovation performance</i>	<i>Cluster 3: Drivers of eco-innovations</i>	<i>N = 9</i> Age span: 2008–2015	De Marchi (2012), Ghisetti, Marzucchi, and Montresor (2015), Triguero, Moreno-Mondéjar, and Davia (2013)	Drivers of eco-innovations, such as financial gains and their effects on innovation performance, including open eco-innovation modes
<i>Organizational behavior</i>	<i>Cluster 4: Organizational ambidexterity</i>	<i>N = 7</i> Age span: 1996–2009	He and Wong (2004), Jansen, Tempelaar, Van den Bosch, and Volberda (2009), Tushman and O'Reilly (1996)	Interplay between exploration and exploitation with respect to antecedents, outcomes, and determinants in ambidextrous organizations
<i>External sources</i>	<i>Cluster 5: Lead user</i>	<i>N = 6</i> Age span: 1945–2010	Franke, Von Hippel, and Schreier (2006), Lilien, Morrison, Searls, Sonnack, and Von Hippel (2002), Von Hippel, Franke, and Prügl (2009)	Lead users as external knowledge source (e.g., for breakthrough innovations), and search strategies to identify rare subjects within a large search landscape
<i>External sources</i>	<i>Cluster 6: Interorganizational knowledge networks</i>	<i>N = 6</i> Age span: 2000–2013	Oerlemans et al. (2013), Voudouris, Lioukas, Iatrelli, and Caloghirou (2012), Wang and Hsu (2014)	Impact and determinants of external search mechanisms relating to knowledge networks in interorganizational settings (e.g., alliance portfolio diversity, interorganizational relationship learning)
<i>External sources</i>	<i>Cluster 7: Knowledge spillovers from academic research</i>	<i>N = 7</i> Age span: 1991–2004	Acs, Audretsch, and Feldman (1994), Mansfield (1991), Mohnen and Hoareau (2003)	Knowledge spillovers from universities and governmental labs relating to, for example, geographical proximity, firm size, and mobility of human capital
<i>Organizational behavior</i>	<i>Cluster 8: Innovation productivity</i>	<i>N = 5</i> Age span: 1998–2008	Crépon, Duguet, and Mairesse (1998), Griliches (1995), Roper, Du, and Love (2008)	Drivers of innovation and productivity with respect to the relationships between innovation output and economic growth, research effort, variety of employee skills, and firm productivity
<i>Organizational behavior</i>	<i>Cluster 9: Organizational responses to external environment</i>	<i>N = 4</i> Age span: 1977–2003	DiMaggio and Powell (1983), Greve (2003b), Oliver (1991)	Organizational responses to change related to, for example, factors in the external environment such as regulations and social norms
<i>Appropriation mechanisms and innovation performance</i>	<i>Cluster 10: Value management of resource recombinations</i>	<i>N = 4</i> Age span: 1995–2008	Alegre, Lapedra, and Chiva (2006), Galunic and Rodan (1998), Kang and Kang (2009)	Creating, appropriating, and measuring the effects of resource recombinations for innovation, relating to, for example, different knowledge sourcing methods or financial performance
<i>External sources</i>	<i>Cluster 11: User innovation communities</i>	<i>N = 4</i> Age span: 1999–2010	Jeppesen and Frederiksen (2006), Raymond (1999), Shah (2006)	User communities as knowledge source and innovation provider with a focus on, for example, motivational factors and governance structures

The outer area of the network mainly comprises smaller clusters that focus on distinct research streams concentrating on partners for innovation activities beyond the boundaries of the firm, such as lead users (cluster 5), interorganizational knowledge networks (cluster 6), knowledge spillovers from academic research (cluster 7), and user innovation communities (cluster 11). Viewed from the perspective of the entire field, these clusters are not only proximately close but also represent an important common research area: specific external knowledge sources for innovation.

Finally, the remaining clusters form a cohesive strip from the periphery to a more central position in between the previously discussed research areas. A large cluster includes most of our most central network publications (cluster 1), and the content of these remaining clusters centers on organizational ambidexterity (cluster 4), innovation productivity (cluster 8), and organizational responses to external environment (cluster 9). Hence, this research area highlights theoretical considerations regarding the organizational behavior underpinning the field.

## Discussion

### *Evolution of the Field of External Knowledge Search*

Our comprehensive analysis helps us to interpret the field and create a framework of key phases. By connecting our centrality analysis to our cluster approach, and by comparing earlier to more recent research foci, we are able to structure the intellectual roots of the field, track the different approaches in each phase, and synthesize a coherent framework of the development of external knowledge search for innovation over time.

*Phase 1: Recognizing the need for search.* Early and key literature in our analysis centers on the theoretical work of Nelson and Winter (1982), March (1991), and Levinthal and March (1993). This research line provided an initial motivation for and recognition of the need for search. Their behavioral theory of the firm conceptualized search activities to break up path dependencies and discover innovations in response to performance shortfalls or a changing environment, which is also known as problemistic search. Firms faced a trade-off between exploration

and exploitation (March, 1991) as a way of adapting to external environmental forces (cluster 9), and search was frequently in the hands of executives who scanned their indigenous business environment to stimulate new strategies or product developments (Aguilar, 1967).

*Phase 2: Organizing search capabilities.* The field of external knowledge search entered a new phase in the 1990s when researchers highlighted external knowledge as an important resource (Kogut and Zander, 1992) that needs to be purposefully integrated into the firm (Cohen and Levinthal, 1990; Zahra and George, 2002). This marked a clear shift from rather erratic CEO actions to the systematic sourcing of knowledge for the firm, underscored by the need to enable absorptive capacity and better organize search capabilities. These insights influenced two research areas. First, a surge in theoretical considerations enriched understanding; for example, the interplay of exploration and exploitation experienced a refinement toward ambidextrous organizations (cluster 4). External search was clearly recognized as a driver of innovation and productivity output (cluster 8). Second, firms leveraged their closer neighborhood of the current knowledge base with interfirm knowledge resources. Firms formed relationships with nearby universities in order to find academic spillovers and employ researchers for product development (cluster 7). To detect future market needs and enhance product innovations, firms reached out to lead users (cluster 9). The growth of systematic integration of different external knowledge sources also nurtured subsequent research on resource recombination in the firm and advanced the understanding of optimal knowledge structures for innovation (cluster 10).

*Phase 3: Leveraging external sources of innovation.* While in phase two external search focused on local search, phase three pointed toward boundary-spanning search practices and questions of where and how to search externally. Where to search describes the search space with respect to whether external search is directed toward local or distant knowledge in relation to the firm's current knowledge stock (Katila and Ahuja, 2002; Rosenkopf and Nerkar, 2001). How to search describes the applied search heuristics with regards to how widely and deeply firms should search externally for increased innovation outputs (Katila and Ahuja, 2002; Laursen

and Salter, 2006). In addition, it became clear that knowledge not only resides in individuals (central to clusters 5 and 7), but also lies in professional knowledge networks (cluster 6). This marked a shift toward more collaborative innovation approaches, which was also evident in community innovation (cluster 11). Furthermore, research under the wide umbrella of open innovation (Chesbrough, 2003; Stanko, Fisher, and Bogers, 2017) advanced the idea that “profit requires both the choice of an innovation and its commercialization strategy to be fully aligned to a firm’s business model” (West and Bogers, 2014, p. 822). Cluster 2 highlights the firm’s commercialization strategy and the realization of value from external knowledge, and, together with Cluster 6, also points toward negative search effects, such as over searching (Laursen and Salter, 2006; Oerlemans, Knobens, and Pretorius, 2013; West and Bogers, 2014). Thus, research in this area points to central shifts within this phase, from research concentrating on protecting knowledge so that imitation and leakage are prevented (Grant, 1996) to transactional knowledge management processes, including formal partner selection and purposeful outbound and inbound of knowledge.

### *Toward a New Phase in External Knowledge Search*

*The concept of decoupled search.* Our review shows two fundamental principles that have so far been taken for granted in the literature. First, the firm as the focal agent is primarily responsible for searching for relevant knowledge and recombining it with existing knowledge. Second, search activities have been characterized as directed, controlled, and proactive, and as having the aim of identifying and evaluating new knowledge (Li et al., 2013). Both principles are found in multiple clusters (e.g., 1, 2, and 10), and they are particularly present in seminal publications of the foundational cluster (e.g., Katila and Ahuja, 2002; Laursen and Salter, 2006; Rosenkopf and Nerkar, 2001).

However, some of the younger clusters (e.g., 11) and more loosely connected clusters, such as research focusing on broadcast search (an emerging cluster only visible in our sensitivity analysis, e.g., Afuah and Tucci, 2012; Jeppesen and Lakhani, 2010), indicate a new search approach that challenges both principles. Research in these clusters is characterized by a shift in organizational search behavior from finding valuable

external knowledge by the focal firm to letting other agents take over. From this perspective, although the focal firm oversees the entire search process and defines the search objective, it might “subcontract” the actual search activity—understood as the exploration of the search landscape for new knowledge—to external agents. This implies that the focal firm itself no longer decides on key search questions, such as where and how to search, instead leaving this decision to the external agent(s). The focal firm may then eventually select the most promising solution among multiple options and, hence, move from ex ante to ex post selection of knowledge to use. The search process is split between the focal agent and a search assistant—a concept that we term “decoupled search.” Since the decoupled search approach distinguishes between the search initiator (the focal firm) and the actual searcher (external agents), it explicitly takes into account who is conducting the search for a specific problem. While external agents conduct the search and come up with potential solutions, the focal firm retains the decision as to which solution to exploit from the (multiple) external contributors. Hence, within the concept of decoupled search, firms give up control over the actual search but win freedom to achieve knowledge transfer and behavioral search advantages. This represents an important landmark, offers a novel perspective on external search behavior, and calls for a new phase.

*A new phase in external knowledge search: Managing the search interface.* The novel search concept of decoupled search characterizes a new phase in external knowledge search for innovation. The search activity is no longer characterized by formal (singular) contractual relationships but, instead, requires organizations to manage distributed and unbounded contributors. This implies that firms have little influence on the search space. In fact, it might be completely unfamiliar and unknown to the firm. We base our interpretation on early clusters and authors, such as Leiponen and Helfat (2010), highlighting multiple parallel search ways as sometimes visible in firm-hosted collaborative communities (Jeppesen and Frederiksen, 2006), on innovation platforms and intermediaries (Howells, 2006), within broadcast search (Jeppesen and Lakhani, 2010), or in open source innovation (Herstatt and Ehls, 2015; Shah, 2006), and innovation contests (Terwiesch and Xu, 2008).

**Table 5. Research Phases of External Knowledge Search**

Phase	Recognizing the Need for Search	Organizing Search Capabilities	Leveraging External Sources of Innovation	Managing the Search Interface
Start	~1963	~1990	~2001	Today
Core authors stimulating research	March (1991), Nelson and Winter (1982)	Cohen and Levinthal (1990), Kogut and Zander (1992)	Katila and Ahuja (2002), Rosenkopf and Nerkar (2001), Chesbrough (2003)	Leiponen and Helfat (2010), Jeppesen and Frederiksen (2006), Poetz and Schreier (2012)
Core search concepts	Problemistic search (Cyert and March, 1963), Exploratory and exploitative search (March, 1991), Organizational learning (Levinthal and March, 1993)	Need to absorb external search input (Cohen and Levinthal, 1990; Zahra and George, 2002)	Experiential and cognitive search (Gavetti and Levinthal, 2000), boundary-spanning search (Rosenkopf and Nerkar, 2001)	Decoupled search
Exemplary re-search topics	Search practices of executives (Aguilar, 1967), organizational adherence and adaptation in response to external forces (DiMaggio and Powell, 1983)	Ambidextrous organizations (Tushman and O'Reilly, 1996), sources of innovation such as knowledge spillovers (Mansfield, 1991) or lead users (Von Hippel, 1986)	Efficient search combination for innovation output (Laursen and Salter, 2006), innovation performance (Alegre et al., 2006) and commercialization of external sources (West and Bogers, 2014)	Intermediaries (Howells, 2006), crowdsourcing (Mannes, Soll, and Larrick, 2014), innovation communities (Jeppesen and Frederiksen, 2006)
Clusters	9	4,5,7,8	2,3,6,10	11
Typical external knowledge sourcing and transfer	Erratic CEO actions, for example, in response to performance shortfall and external forces	Benefitting from spillovers and ambidextrous search	Commercial transactions between firm and its partners	Informal relations to distributed unbounded contributors
Typical external knowledge search space	Monitoring indigenous environment and responding to policy requirements	Neighborhood of the firm's current knowledge, for example, spillovers from academia (cluster 7) and lead users (cluster 5)	Distant search in other industries and technological fields (e.g., Rosenkopf and Nerkar, 2001) and inter-organizational knowledge networks (cluster 6)	Unknown and potentially unfamiliar to the firm
Locus of knowledge recombination	Firm internal	Firm-centric	Network-centric	Decoupled-knowledge-source-centric

Thus, while traditionally external knowledge search has centered on describing search paths for knowledge recombination under the full control of the firm, central to this latest yet still emerging phase is a focus on managing the interface between the focal firm and (informal) search agents who are potentially quite distant from the firm's current knowledge base. This also goes beyond the absorption of external knowledge (Cohen and Levinthal, 1990), because a "broadcasting" capability is now required for effective knowledge transfer to distributed solvers. Firms want to unlink need formulation from solution identification in the search process, and to empower external agents to combine suitable knowledge pieces.

Based on this reasoning, we see a strong indication for a new phase in external knowledge search research: the phase of managing the search interface with the decoupled search at its core. All four phases, including key criteria, are shown in Table 5. Notably, later phases do not replace earlier phases; rather, they offer extended opportunities.

**Future Research Avenues**

Our analysis and discussion point toward three research areas for which we present future research directions with the possible theories that apply to them (Table 6).

**Table 6. Future Research Avenues**

Research Area	Research Gap	Potential Research Questions	Theories/Concepts that Can Be Applied
External sources	Attracting and identifying solvers	<ul style="list-style-type: none"> <li>How can companies optimize initiatives for leveraging the crowd (e.g., awards, number of participants, task size, etc.)?</li> <li>How can unique external sources be found before competitors find them and how can they be prevented from providing knowledge to competitors?</li> <li>What are the potential new sources to tap into (beyond communities, user, crowdsourcing)?</li> <li>Which approaches should firms employ and when should they reach distributed solvers, for example, open calls versus pyramiding?</li> <li>Which of the multiple external sources is most promising and under which objectives (e.g., click workers versus firm-hosted community for innovative ideas)</li> <li>How can requirements be communicated to external solvers?</li> <li>What information should the problem statement include?</li> <li>How much information should it include, and which of its elements and combinations in the search query drive which results</li> <li>How can relationships be built with sources that are thus far unknown and decoupled?</li> <li>How can firms build a reputation for trust and good relationships and what are fair deals for knowledge transactions?</li> <li>How do professional networks (e.g., firm alliances) differ from decoupled solvers (e.g., user communities) and what does it mean for joint innovation development?</li> <li>Can participants learn and can firms train solvers to provide better solutions?</li> <li>How can respondents who do not succeed be satisfied in order not to lose them?</li> <li>What do resilient relationships look like and what are conflict mitigation practices?</li> </ul>	<ul style="list-style-type: none"> <li>Contest theory (Che and Gale, 2002; Terwiesch and Xu, 2008)</li> <li>Knowledge brokerage (Hargadon and Sutton, 1997)</li> </ul>
	Problem formulation	<ul style="list-style-type: none"> <li>How can requirements be communicated to external solvers?</li> <li>What information should the problem statement include?</li> <li>How much information should it include, and which of its elements and combinations in the search query drive which results</li> <li>How can relationships be built with sources that are thus far unknown and decoupled?</li> <li>How can firms build a reputation for trust and good relationships and what are fair deals for knowledge transactions?</li> <li>How do professional networks (e.g., firm alliances) differ from decoupled solvers (e.g., user communities) and what does it mean for joint innovation development?</li> <li>Can participants learn and can firms train solvers to provide better solutions?</li> <li>How can respondents who do not succeed be satisfied in order not to lose them?</li> <li>What do resilient relationships look like and what are conflict mitigation practices?</li> </ul>	<ul style="list-style-type: none"> <li>Problem formulation (Baer et al., 2013; Volkema, 1983)</li> </ul>
	Building relationships and collaborating with solvers	<ul style="list-style-type: none"> <li>How can relationships be built with sources that are thus far unknown and decoupled?</li> <li>How can firms build a reputation for trust and good relationships and what are fair deals for knowledge transactions?</li> <li>How do professional networks (e.g., firm alliances) differ from decoupled solvers (e.g., user communities) and what does it mean for joint innovation development?</li> <li>Can participants learn and can firms train solvers to provide better solutions?</li> <li>How can respondents who do not succeed be satisfied in order not to lose them?</li> <li>What do resilient relationships look like and what are conflict mitigation practices?</li> </ul>	<ul style="list-style-type: none"> <li>Relational view (Dyer and Hatch, 2006; Dyer and Singh, 1998)</li> <li>Rotating leadership (Davis and Eisenhardt, 2011)</li> <li>Learning theory (Argote and Epple, 1990; Brown and Duguid, 2000; Foster and Rosenzweig, 1995)</li> </ul>
Org. search behavior	Routines for integration and transfer of external knowledge	<ul style="list-style-type: none"> <li>What can companies do to align organizational needs to ideators' efforts and how should companies organize their external search routines?</li> <li>Are routines created for formal knowledge transaction still applicable today with decoupled sources and what specific routines and capabilities do we need for external search?</li> <li>What is the impact of different social processes of knowledge transmission?</li> <li>Should companies employ (several) specialists or generalists at the interface?</li> <li>What governance mechanism do firms need for a pluralism of decoupled search partners?</li> </ul>	<ul style="list-style-type: none"> <li>Capabilities perspective (Hargadon and Sutton, 1997; Kogut and Zander, 1992)</li> <li>Sticky information (Von Hippel, 1998)</li> <li>New organizational practices (Foss et al., 2011; Biancani et al., 2014)</li> <li>Jack-of-all-trades view (Lazear, 2004; Teodoridis, Bikard, and Vakili, 2019)</li> <li>Network theory (Nambisan and Sawhney, 2011)</li> </ul>

**Table 6. Continued**

Research Area	Research Gap	Potential Research Questions	Theories/Concepts that Can Be Applied
	Search bias and sense making	<ul style="list-style-type: none"> <li>• What can firms do to avoid the competence-maturity trap and go in truly novel directions?</li> <li>• How can firms overcome the tendency of incremental changes, and how can they identify more abstract relationships for breakthrough innovations?</li> <li>• How can firms train employees to be open-minded about unfamiliar knowledge and counter myopic tendencies toward search results?</li> <li>• How can firms connect different repertoires of tacit knowledge at the interface of the firm with decoupled solvers?</li> </ul>	<ul style="list-style-type: none"> <li>• Behavioral strategy (e.g., mental representation and the discovery of new strategies, heuristics and prospect theory: Tversky and Kahneman, 1974, 1979), as well as “rugged performance landscape” (Levinthal, 1997)</li> <li>• “Not invented here” syndrome (Antons and Piller, 2015)</li> <li>• Analogies (Gentner, 1983; Holyoak and Thagard, 1996), selective attention (Daft and Weick, 1984; Ocasio, 1997)</li> <li>• Knowledge in practice view (Carlile, 2002; Orlikowski, 2002)</li> <li>• Forward-looking search (Chen, 2008; Gavetti and Levinthal, 2000)</li> <li>• Corporate foresight (Rohrbeck, Battistella, and Huizingh, 2015; Rohrbeck and Gemünden, 2011)</li> </ul>
	Forward-looking search and environmental shaping	<ul style="list-style-type: none"> <li>• How does a firm’s own understanding of external search results influence organizational adaptations, spur innovation, and respond by shaping its endogenous business environment?</li> <li>• Should companies focus on one solution (as is frequently done today) or follow multiple paths and pursue parallel play?</li> <li>• Going beyond specific search, how should a firm anticipate and monitor a dynamic environment and peripheral player to increase understanding of innovations and upcoming disruptions?</li> </ul>	
Search performance management	Measurement and KPI	<ul style="list-style-type: none"> <li>• How can agreement be achieved about the value of external knowledge?</li> <li>• What KPIs should companies use to measure external search performance and manage the trade-off between shortsighted risk-averse behavior and unfamiliar powerful knowledge sourcing?</li> <li>• Are measurements identical for product, process, and service innovations?</li> <li>• How can the optimal point of search breadth be determined, and can oversearch be avoided?</li> <li>• How can firms keep control of decoupled contributors, and how can they monitor actions beyond firms’ control?</li> </ul>	<ul style="list-style-type: none"> <li>• Measurement of innovation (Del-Rey-Chamorro et al., 2003)</li> <li>• Diversification and risk-taking (Hoskisson et al., 1991)</li> </ul>
	Timing	<ul style="list-style-type: none"> <li>• How do search efforts unfold over time, and when do firms leave search paths?</li> <li>• What is an appropriate sequencing of different search efforts and what is the optimal pace for renewing search results?</li> <li>• When do firms start to explore novel terrain beyond problematic or slack search?</li> <li>• Are decoupled search activities connected to longer term horizons (and more sustainable growth and disruptive innovations)?</li> </ul>	<ul style="list-style-type: none"> <li>• Timing of innovation (Eggers and Kaul, 2018; Greve, 2003a)</li> <li>• Recency perspective (Heeley and Jacobson, 2008; Katila, 2002; Nerkar, 2003)</li> </ul>

Table 6. Continued

Research Area	Research Gap	Potential Research Questions	Theories/Concepts that Can Be Applied
	Contingencies	<ul style="list-style-type: none"> <li>• Under which conditions is one search approach more valuable than another?</li> <li>• What is the object of search and how does it affect the search?</li> <li>• What are winning combinations of multiple external sources?</li> <li>• Should different firm types (e.g., a multinational company, a family firm, a market pioneer, or a follower) rely on different search approaches?</li> <li>• What are boundary conditions for knowledge sourcing and when should companies not draw on decoupled solvers?</li> </ul>	<ul style="list-style-type: none"> <li>• Contingency view (Chatterji and Fabrizio, 2014; Teece, 1986)</li> <li>• Search objects and combinations (Crisuolo et al., 2018; Jung and Lee, 2016; Kaplan and Vakili, 2015)</li> </ul>
	Knowledge processing and overload	<ul style="list-style-type: none"> <li>• How can firms manage not only the sheer quantity of external knowledge but also the abundant combinations of that knowledge in order to carry out knowledge recombination?</li> <li>• How can firms master the trade-off between lower direct search costs and higher costs for problem formulation and solution selection?</li> <li>• Which structures are required to “park” knowledge without deterioration and quick reactivation?</li> <li>• How can data management systems support, retain, and pass memory across boundaries?</li> <li>• What are the implications of the digitalization of knowledge?</li> <li>• How can modern technologies (e.g., AI, block chain) and analytics (semantic analysis, topic mapping) help identify relevant knowledge even from unfamiliar fields?</li> <li>• Can digital simulations of knowledge recombination indicate unforeseen radical innovations?</li> </ul>	<ul style="list-style-type: none"> <li>• Decomposition and coupling of knowledge (Yayavaram and Ahuja, 2008)</li> <li>• Information repository and transactive memory systems (Lewis and Herndon, 2011; Ren and Argote, 2011)</li> <li>• Digitalization of knowledge (Nambisan, Lyytinen, Majchrzak, and Song, 2017; Verganti et al., 2020; Yoo, Boland, Lyytinen, and Majchrzak, 2012)</li> </ul>

### *External Knowledge Sources*

Our results reveal multiple ways for firms to leverage external knowledge sources. However, as external search moves toward more unfamiliar search spaces and more informal sources, several questions remain underexplored.

*Attracting and identifying knowledge sources.* So far, most external sources are relatively familiar to the firm, for example, partnering firms, universities, or even firm-hosted user communities. However, we expect a shift toward more unfamiliar solvers and multiple external sources. In the decoupled approach, firms relinquish control over the search process and reach out to unfamiliar solvers. Thus, solution seekers need to find ways to attract and identify promising external sources. However, this research is less prominent in our analysis. Given the increased number of external knowledge sources, we need a better understanding of which sources are most promising, under which conditions, and how to reach them. For example, broadcast search is unseen in our analysis and points to a weaker integration. To identify promising sources, gamification settings could help attract decoupled sources, as well as insights from knowledge brokering theory (Hargadon and Sutton, 1997). Moreover, contest theory (Che and Gale, 2002; Terwiesch and Xu, 2008) provides another starting point and highlights how incentives and group sizes of participants can affect results.

*Formulating the problem statement.* Research on the activity of search has flourished, but, surprisingly, that on strategic formulation for conducting the search has been taken for granted and is largely underexplored. However, such research is important as it not only encourages firms to give stronger consideration to the real search problem (Baer, Dirks, and Nickerson, 2013; Volkema, 1983) but also opens new avenues to connect and influence search partners at the interface in order to achieve superior search results. Specific research questions might relate to how to write the problem statement and how much information it should include, as well as to which elements and combinations thereof in the search query drive which results. Thus, the problem statement exhibits a novel way to leverage the full creativity of external input for innovations.

*Building relationships and collaborating with decoupled solvers.* External search requires interaction with external knowledge sources. Currently, most interactions with external sources are rather formal and repetitive, and we have limited understanding of informal and one-time interactions, which will potentially increase with decoupled search activities. However, research in the field of external search is lacking on how to move from transactional to relational relationships. Insights from user innovation show that users and firms are motivated by different rationales (cluster 5). Relational theory (Dyer and Singh, 1998) could provide valuable insights into creating resilient social bonds, fostering a climate of mutual trust, and ensuring sustainable and fair transactions. Moreover, a rotating leadership (Davis and Eisenhardt, 2011) perspective might explain why some relationships produce success in collaborative innovations, whereas others fail in knowledge recombination. Finally, drawing more strongly on learning theory (Foster and Rosenzweig, 1995) might increase our understanding of how to train external solvers and of how managers walk the fine line between stimulating and killing external relationships; for example, it might enhance understanding of how to respond to unsuccessful sources while also building trust and symbiotic relationships.

### *Organizational Search Behavior*

Entering a new phase of managing the search interface involves challenges for the internal organization of search behavior. Hitherto, there has been a strong focus on absorbing (transactional and rather familiar) knowledge, whereas our understanding requires a reflection on new opportunities.

*Routines for integration and transfer of external knowledge.* Despite the management of knowledge development (Teece, 1986) and the behavioral theory of the firm highlighting the importance of routines for innovation and knowledge transfer (Cyert and March, 1963; March and Simon, 1958; Nelson and Winter, 1982), research on routines is, surprisingly, only marginally seen in our analysis. While re-ordering of routines can lead to new knowledge recombination that fosters innovation (Galunic and Rodan, 1998; Kogut and Zander, 1992), a stronger integration of dynamic capabilities, absorptive capacity, the behavioral theory of the firm, and the knowledge-based view would

strengthen our understanding, especially by detailing the concept of combinative capabilities important for external knowledge search (Kogut and Zander, 1992). Defining effective structures, roles, and search routines facilitates the move from an ad hoc approach to more institutionalized practices and, thus, to a professionalization of external search activities.

Moreover, it remains unclear which roles and skills firms require for identification, evaluation, and selection. For example, should firms draw on several specialists or generalists at the interface for interaction with external partners? An emerging stream of “jack-of-all-trades” studies (Lazear, 2004; Nagle and Teodoridis, 2019) might provide fruitful insights. It is also unclear what government mechanisms work to benefit multiple search partners. Network theory could, here, provide insights into the orchestration of network-centric innovation (Nambisan and Sawhney, 2011), as can research on semi-formal organizations (Biancani, McFarland, and Dahlander, 2014), and rethinking of organizational practices (Foss, Laursen, and Pedersen, 2011).

*Search bias and sense making.* A longstanding issue in external knowledge integration is cognitive bias (March and Simon, 1958), which hinders the effective filtering and recombination of knowledge. However, this issue is heightened by moving from rather familiar to unfamiliar knowledge sourcing, because firms prefer local knowledge (Piezunka and Dahlander, 2015) and medium new ideas (Criscuolo, Dahlander, Grohsjean, and Salter, 2017). Ideas for avoiding this competence trap could come from behavioral strategy and new mental representations (Csaszar and Levinthal, 2016), heuristics and prospect theory (Tversky and Kahneman, 1974, 1979), and selective attention theory (Daft and Weick, 1984; Ocasio, 1997). In addition, innovation management itself has a rich history of insights from the “not invented here” syndrome (Antons and Piller, 2015) and research on analogies (Gentner, 1983; Holyoak and Thagard, 1996; Kalogerakis, Lüthje, and Herstatt, 2010).

*Foresight and environmental shaping.* Most innovation progression is evolutionary and grounded in experience-based search behavior (Gavetti and Levinthal, 2000). As such, moving from backward- to forward-looking search behavior is essential not only to overcome organizational inertia but also to enable the appropriate interpretation of distant

knowledge that goes beyond chance and serendipity as inherent in the bounded rationality in the behavioral understanding of the firm.

This has significant implications for external knowledge search. First, a firm should scan its environment more broadly to identify trends and spot breakthrough knowledge early. This enables the fuller understanding of a dynamic environment necessary for achieving superior courses of action (Gavetti and Menon, 2016). In this regard, literature on foresight could provide fruitful approaches to the anticipation of consequences; as yet, however, it is not present in the field of external knowledge search (Rohrbeck and Gemünden, 2011; Rohrbeck and Kum, 2018). Second, forward-looking search enables a firm to shape its endogenous environment in an unprecedented way. This is vital because firms move from adapting in a reactive way to forming their environments in an active way in order to achieve superior courses of actions. Although this environmental shaping has been little explored, it strongly informs decision-making about firms’ R&D search (Chen, 2008).

#### *Appropriation Mechanisms and Innovation Performance*

The latest research clusters point toward the importance of value-capture antecedents and innovation performance. These clusters are the youngest research area, and there are many opportunities to dive deeper into performance aspects and management of external search for innovation.

*Measurement and control.* Our anticipated phase of managing the interface includes a higher number of external sources as well as new types of external sources. Both aspects pose challenges for firms with respect to how they control and measure their external search efforts, especially as firms give up control over the search process. As managers frequently behave in a risk-averse way, prefer shortsighted ideas (Criscuolo, Dahlander, Grohsjean, and Salter, 2017; Piezunka and Dahlander, 2015), and are driven by financial measures instead of risky long-term objectives, they tend to prefer exploitation over exploration, but this comes at the cost of long-term success. However, this situation is meant to become worse, as managers need to decide about more and rather unfamiliar knowledge. It is thus essential to develop clearer measurement instruments and key performance indicators so that

the value of external knowledge can be determined. The literature provides helpful insights into key performance indicators for knowledge management solutions (Del-Rey-Chamorro, Roy, Van Wegen, and Steele, 2003) and managerial risk-taking in diversified firms (Hoskisson, Hitt, and Hill, 1991).

*Effects of timing.* The behavioral theory of the firm has already pointed toward timing by highlighting how performance below aspiration levels is a trigger for when to conduct search activities (Cyert and March, 1963). Our study shows that, surprisingly, there is little research on the dynamics of search. There are a few insights into how search activities develop over time, appropriate search sequences, and whether longer search activities really pay off (or whether they do not cover the higher search costs). In addition, prior research provides some starting points (Greve, 2003a), and recent studies have extended these research lines by analyzing the effects of search timing on innovation (Katila and Chen, 2008) and when firms have the highest motivation to pursue radical innovations (Eggers and Kaul, 2018). However, analysis of time-related aspects remains scarce and there remains little understanding of when search is optimal during the innovation phase and how further timing aspects might affect external search.

*Contingencies.* The contingent outcome of external search already manifests itself in key publications reviewed in our research (e.g., Katila and Ahuja, 2002). Recent research has picked up this perspective and gone beyond the questions of where and how to search by adding a new dimension: what is the object of search and what are its effects on breakthrough innovation (Kaplan and Vakili, 2015; Jung and Lee, 2016)? In this regard, we have already highlighted “when” and “who” as further pointers. Building on this research and revealing interactions in search paths might lead to a refined understanding of external search. We know little of the conditions under which one search approach is more valuable than another. Moreover, we do not fully comprehend the winning combinations of multiple external sources (Crisuolo, Laursen, Reichstein, and Salter, 2018), or the suitable search approaches for different types of firms (large or small, market pioneer or follower). In addition, the literature shows negative aspects of search, such as oversearch and large search costs

(Laursen and Salter, 2006). However, we lack a refined understanding of boundary conditions for external knowledge search and of when external search does not enhance innovation performance.

*Knowledge processing and overload.* While external search advances the pool of potential knowledge recombination important for innovation, this comes at a price: it generates a plethora of knowledge that needs to be organized. Individuals face at least two challenges in this regard: limited cognitive capabilities to remember (all) knowledge; and decision-making being made more difficult by too much information. This information overload impedes the processing of knowledge and ultimately leads to reduced innovation performance. Indeed, while external knowledge search aims to increase the available knowledge base, information overload counteracts the ability to leverage the full knowledge base.

Although the field has paid limited attention to these downsides, fruitful insights can be gained from theory on information repository and transactive memory systems (Lewis and Herndon, 2011; Ren and Argote, 2011) and on decomposition and coupling of knowledge (Yayavaram and Ahuja, 2008). Moreover, by applying the latest technology and digital approaches to knowledge processing, entirely new opportunities can be opened up. For instance, smart algorithms are able to detect scientific laws unfamiliar to humans (Schmidt and Lipson, 2009), and the provision of published studies to a machine-learning setup has resulted in the detection of new laws for material science (Tshitoyan et al., 2019). Clearly, these opportunities go beyond cost optimization of external search and we are only beginning to understand the larger impact on innovation management (Verganti, Vendraminelli, and Iansiti, 2020). This impact relates to questions such as: How can modern technologies (e.g., artificial intelligence, blockchain) and analytics (e.g., semantic analysis, topic mapping) help us identify relevant knowledge even from unfamiliar fields? Can digital simulations of knowledge recombination point us to unforeseen radical innovations?

## Conclusion and Implications

As the first systematic and comprehensive review of the field of external knowledge search for innovation,

our co-citation analysis makes an empirical contribution. Furthermore, we contribute to theory. First, our synthesis of a fragmented research field, which includes our framework of the development of search practices, reconciles approaches to innovation stimulation. Second, we propose a novel search concept and generated the idea of “decoupled search,” which enriches our understanding of knowledge recombination. We also derive managerial implications from our analysis.

### *Offering a Synthesis of a Fragmented Research Landscape*

Innovations result from useful knowledge recombination, and searching externally for knowledge promises to be particularly fruitful. However, the field of external knowledge search for innovation is heavily fragmented and spans several disciplines, such as innovation management, strategy, and general management. Targeting this gap, our study advances our understanding by presenting a comprehensive synthesis (Gatrell and Breslin, 2017; Post et al., 2020; Rousseau et al., 2008). By integrating different research clusters and central publications across disciplines in order to construct a unified and cohesive framework, we add new ways of seeing the literature (Shaw et al., 2008). Our research offers a global view on how recent studies have progressed from earlier concepts and how the focal contexts have altered.

This global view also resolves certain controversies in the field. For example, there exists conceptual ambiguity due to the notion of distant search being defined in different ways—for example, with respect to external search in the closer neighborhood of the firm’s current knowledge or as targeted at foreign knowledge areas by searching in other industries and technological fields (Li, Vanhaverbeke, and Schoenmakers, 2008; Rosenkopf and Nerkar, 2001). Our results shed new light on this controversy and explain why this ambiguity exists. Whereas earlier research concentrated on search beyond the organizational boundary of the firm in neighboring knowledge areas, more recent studies have increasingly focused on areas that are completely unfamiliar to the firm with respect to its current knowledge base (Afuah and Tucci, 2012; Jeppesen and Lakhani, 2010). Our results highlight these different viewpoints, such as in relation to the applied search

space. Accordingly, we not only answer the call from *JPIM* to delineate stronger links among neighboring disciplines, including the larger management literature on innovation (Sarin et al., 2018), but we also bridge related work across domains, thereby both reducing encapsulation and bias arising from paradigmatic rigidity (Ahuja and Lampert, 2001; Kogut and Zander, 1992) and maximizing theoretical understanding for impactful research (Zahra and Newey, 2009).

### *Proposing a Novel External Search Concept*

A central question in innovation management and the knowledge-based view is how knowledge acquisition from external sources is managed by organizations (Teece, 1986). Our novel concept of decoupled search contributes to answering this question and offers new ways of thinking, at least in two aspects essential in external knowledge search for innovation: origin of knowledge recombination, and knowledge transfer.

First, decoupled search shifts the locus of knowledge recombination from a network-centric perspective to a decoupled-knowledge-source-centric perspective. While the typical search space in the former approach focuses on inter-organizational knowledge networks and, potentially, other industries and technology fields, the search space in the latter approach is unknown and potentially unfamiliar to the firm. This has important implications for the search practice of the firm. Traditional search practices suffer from path dependency (Ahuja and Lampert, 2001; Levinthal and March, 1981), cognitive inertia (Duncker, 1945; Gordon, 1961), and challenges of “sticky” knowledge communication (Von Hippel, 1998), all of which potentially limit more effectual knowledge recombination. In a decoupled approach, however, knowledge recombination relating to new ideas or solutions is developed independently of the firm’s internal routines, because the recombination, by being in the hands of external agents, lies beyond the firm. Since the search activity can be shifted toward a broad range of external agents, who are likely to follow heterogeneous search paths in different areas of the search landscape, more diverse and distant outcomes can be expected. Indeed, since diverse external agents search in their specialist knowledge areas, they can envision novel solutions and consider a larger section of the search landscape compared to a limited number of

in-house staff (Jeppesen and Lakhani, 2010). Sticky local knowledge remains at its origin and needs to be transferred not directly but, rather, in the form of resulting ideas or solutions (Von Hippel, 1994). Hence, knowledge recombination results are less dependent on current routines and can go beyond the prevailing local search behavior of the firm (Dosi, 1982).

Second, knowledge sourcing and transfer approaches for new knowledge have thus far been mainly commercial transactions between the firm and its formal partners. Especially in collaborative new product development, interfirm knowledge transfer and generation are bound to involve selecting knowledge partners *ex ante* (Emden, Calantone, and Droge, 2006), with the result that there are contractual risks and issues relating to power balance (Williamson, 2002). Decoupled search, with its focus on informal relations with distributed unbounded contributors, offers new opportunities in the selection of partners and the management of contractual risks. While the outcome of a decoupled search approach is still undetermined *ex ante* (Nelson and Winter, 1977; Rosenberg, 1976), it can be determined before the actual integration since search results are provided up front by the external search agent.

Hence, the decoupled search approach not only counteracts contractual risks associated with joint knowledge development, but also enables the firm to explore a variety of search results and to determine *ex post* the suitability of offered ideas (Pich, Loch, and Meyer, 2002). This is especially important for innovation management. A large number of research and development projects fail, and their outcome is unclear. This introduces not only huge sunk costs for corporations but also lost development time and reduced speed to market. As such, the decoupled search approach purposefully draws on multiple parallel ways to reduce the risk inherent in innovation activities (Leiponen and Helfat, 2010). It responds to the call to further detail search practices (Felin and Zenger, 2014; Jeppesen and Lakhani, 2010) and provides an answer to the still burning question of how organizations can search more efficiently and leverage the knowledge of distributed minds (Felin and Zenger, 2014; Hayek, 1945).

### *Implications for Practice*

Our co-citation analysis and the resulting synthesis informs managers about the vast thinking in the

field. In particular, our phase framework highlights the evolution of the field and provides a comprehensive overview of the main principles. It shows managers the different approaches to conducting external knowledge search for innovation, and managers might draw on them to increase their understanding and, consequently, to realign their innovation activities. Moreover, cutting-edge managers might leverage our future research directions to ponder on open quests for their external knowledge search activities and thus to come up with novel solutions that increase their search performance.

Additionally, in raising awareness of the decoupled search approach, we enrich managers' understanding of possible search strategies and point them toward the importance of managing the interface with unbounded contributors. This approach challenges established managerial thinking because it involves giving up control over the search process; however, this yields several advantages and enables ideas to be received from unfamiliar knowledge sources. Indeed, it might be unprecedented for many firms to allow the essential role of knowledge recombination to take place independently of the firm, and to shift from conducting their own corporate research and development exploration activities to managing them and reaching a new level within a knowledge-based company.

### *Limitations*

The field of external knowledge search has a strong tradition, which has been synthesized in our co-citation analysis. However, our systematic review approach has some limitations. Due to the pluralism of the field, no commonly agreed key term exists. We addressed this issue by following former reviews and creating a search string derived from external search descriptions and key articles in the field. Further limitations of a co-citation analysis include its discrimination against very recent articles and a lack of objective criteria for selecting network thresholds. We aimed to mitigate these drawbacks via a network sensitivity analysis, which confirms the robustness of our results and increases confidence in the findings. However, we acknowledge that other thresholds or another approach may lead to slightly different network structures, and those very recent publications could be missing from our network.

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