Search and Recombination Process to Innovate: A Review of the Empirical Evidence and a Research Agenda

RECOMBINATIONS AND SEARCH MECHANISMS TO INNOVATE. A REVIEW OF THE EMPIRICAL EVIDENCE AND A RESEARCH AGENDA

TOMMASO SAVINO*
Research Fellow
Politecnico di Bari
Bari 70126 – Italy
telephone number: 0039-080-5962847
e-mail: tommaso.savino@poliba.it

ANTONIO MESSENI PETRUZZELLI
Lecturer
Politecnico di Bari
Bari 70126 – Italy
telephone number: 0039-080-5962776
e-mail: antonio.messenipetruzzelli@poliba.it

VITO ALBINO
Professor
Politecnico di Bari
Bari 70126 – Italy
telephone number: 0039-080-5962759
e-mail: vito.albino@poliba.it

May 2014

*Corresponding author.

Keywords: innovation; recombination; search; systematic literature review, firms.

RECOMBINATIONS AND SEARCH MECHANISMS TO INNOVATE. A REVIEW OF EMPIRICAL EVIDENCE AND RESEARCH AGENDA

Abstract

The fundamental role recombination and search mechanisms play in the creation of innovation is widely recognised in the innovation management literature. However, the academic attention given to this topic has provided complex, fragmented, and mixed results. Hence, we aim to identify areas of convergence and provide directions for future research by collecting empirical evidence regarding recombination and search mechanisms from the literature on innovation management. Accordingly, we conducted a systematic literature review of 98 articles. The resulting empirical evidences are analysed at the inventor and firm levels. Based on this framework, the review underlines the critical role of variety and diversity of knowledge elements to create breakthrough innovations. Therefore, the paper discusses ways to provide access to different and various knowledge elements. In addition, we highlight other fundamental questions calling for further investigation, such as how scientific and aged knowledge elements are successfully recombined, as well as how recombination and search dynamics occur in small and medium-sized firms. The review concludes with a summary of the current state of affairs and traces promising directions for future investigation.

Introduction

Firms and nations, both advanced and developing, can establish and maintain international competitive success by continually developing innovations (Mytelka 1999; Porter 2000). Indeed, innovation heavily influences the growth and productivity of nations and regions (e.g. Mowery and Rosenberg 1979; Sternberg 2000; Eurostat 2001; Simmie 2003). Furthermore, firms innovate to adapt themselves to changing markets (Schoonhoven et al. 1990; Gopalakrishnan and Damanpour 1997; Hurley and Hult 1998; Amit and Zott 2001), to improve market share and market value (Chaney and Devinney 1992; Zahra et al. 2006; Banburry and Mitchell 2007), and to achieve long-term survival and competitiveness (e.g. Zander and Kogut 1995).

The rise of innovation in several sectors is increasingly explained by adopting the recombinant perspective. In fact, research in biotechnology (Sørensen and Stuart 2000), aerospace (Majchrzak et al. 2004), mechatronics (Freddi 2009), and cultural and creative industries (Hirsch 1972, 2000; Boxenbaum and Batilana 2005) have followed the idea that innovation results from a new combination of existing conceptual and physical elements. This is the case in 'Les Demoiselles d'Avignon', one Picasso's most famous paintings, which combines elements as diverse as Iberian sculpture, African tribal masks, and El Greco's painting (Messeni Petruzzelli and Albino 2012). Further examples may be found in high-technology products, such as the video-tape recorder (VTR), which was developed by combining existing elements such as lateral scanning with rotating heads and wideband video recording capability with new mathematical analysis linked to the VTR FM system and transmission of television images using an FM system (IIT Research Institute 1968).

The view of innovation as a new combination of already existing components was initially proposed by Shumpeter (1939) and then adopted by many other scholars in the last century (e.g. Nelson and Winter 1982; Henderson and Clark 1990; Kogut and Zander 1992) and in more recent times (e.g. Fleming 2001; Arthur 2007; Ahuja et al. 2008). In addition, the recombination of elements has been used to explain the change in economic systems (Potts 2000). In fact, a line of inquiry has aimed to understand recombinant processes of knowledge components through which individuals, organisations, industries, and regional areas create new products or processes (e.g. Moran and Ghoshal 1999; Gavetti and Levinthal 2000; Fleming 2001; Katila and Ahuja 2002). Consequently, the ability to recombine knowledge creatively has been identified as a key intangible asset that helps explain a substantial amount of the performance heterogeneity among economic actors (Belenzon 2012).

Within the recombinant perspective, new combinations first occur in the neighbourhood of the knowledge acquired by individuals and firms (e.g. Simon 1978; Fleming 2001), making the exploitation of the cumulated knowledge the starting point (March 1991; Levinthal and March 1993). In fact, actors tend to develop familiar novel combinations based on incremental changes (Dosi 1982; Vincenti 1990; Green et al. 1995; Fleming and Sorenson 2004), thus following an evolutionary model (e.g. Rogers 1995; Ziman 2000; Breslin 2011). However, scholars have underlined the necessity of searching for knowledge components in domains distant from the current knowledge bases of individuals and firms (e.g. March 1991). This exploration effort can be made across different industrial (Phene et al. 2006), organisational (Miller et al. 2007), and geographical (Rosenkopf and Almeida 2003) landscapes. The result of this explorative approach is increased knowledge variety, which is recognised as the basis for developing breakthrough innovations (Stuart and Podolny 1996; Ahuja and Lampert 2001; Rosenkopf and Nerkar 2001; Rigby and Zook 2002; Phene et al. 2006; Gilsing et al. 2008; Leiponen and Helfat 2009). Consequently, in the attempt to find new knowledge components, companies have changed their methods to generate innovation (David 1998; von Hippel 2001; Chesbrough 2003; von Hippel 2005). In the new model of open innovation, firms search for knowledge components from external actors, which are either organisations or individuals not employed by the searching firm, aiming to bring together different knowledge bases distributed across the world (von Hippel 2001, 2005; Benkler 2006; Dahlander and Gann 2010). Nevertheless, the external search for knowledge components may be influenced by institutional factors such as internal firm organisation, inter-firm agreements, and capital market structures (e.g. Teece 1996). In addition, the choices regarding unknown knowledge components may be affected by the social surroundings in which individuals or firms operate. Indeed, the indissoluble connection between actors and society, defined as embeddedness (e.g. Polanyi 1944), develops a system of judgments through which individuals and firms make decisions in uncertain situations such as the exploration of unknown domains (Dacin et al. 1999; Beckert 2003). Thereby, organisations have to manage the combination of new external knowledge components with their own stock of knowledge, and both scholars and practitioners have found evidence of the importance of further analysis of recombinant dynamics to make the recombinant process less time consuming and uncertain (Jacobson and Prusak 2006).

Accordingly, in the present study, we intend to collect empirical evidence regarding recombination and search mechanisms provided by the research literature on innovation management. Thereby, this paper provides a systematic literature review and presents a

multilevel perspective of innovation phenomena (Gupta et al. 2007) based on recombination and search processes. The empirical evidence resulting from the systematic literature review is divided at two levels of analysis: the inventor level and the firm level. In addition, the firm-level analysis includes solutions and strategies occurring both within and across organisational boundaries. Furthermore, we aim to identify salient research gaps and suggest directions for future research.

The paper is organised as follows. First, a theoretical framework is developed to introduce the literature about recombination and search mechanisms that unfold into innovative processes. Second, we explain the search methodology applied in this review. Third, we summarise the areas of convergence of key aspects of recombination and knowledge search elements. The last section provides an overview of the key findings and an outlook for future research.

Theoretical Background

The idea of innovation as a recombination process of already existing elements is an intuition emerged during the first decades of the last century. The idea was elaborated by Ribot (1906), a psychologist, who wrote that creative thinking produces novel combinations and very original inventions. This approach was followed by Ogburn (1922), a sociologist, who associated the development of innovation to a number of cultural elements and their combinations. In addition, Usher (1929) argued that the most relevant characteristic of innovation is establishing relationships that did not previously exist. These ideas were summarised by Gilfillan (1935), who explained the case of the sailing ship that was improved when new components such as steel and steam engines were introduced into the technological environment and integrated into the traditional design. Schumpeter (1939, p. 88) introduced the notion of recombination in economics when he wrote that ‘innovation combines components in a new way, or it consists in carrying out new combinations’. Furthermore, Nelson and Winter (1982) stated that novelty in art, science, or practical life essentially consists of a recombination of conceptual and physical components that were previously in existence. Some years later, Henderson and Clark (1990) proposed the notion of architectural innovation by making the distinction between components and the way in which these components are linked together. In order to generate novelties from different recombinations of existing elements, Kogut and Zander (1992) then introduced the concept of combinative capabilities, seen as the capability of the firm to generate new applications from existing knowledge. These concepts represent the milestones of a specific literature stream that has the

purpose of understanding the role of components and combinations in designing successful innovative solutions. Nevertheless, Arthur (2007) highlighted that new combinations and the satisfaction of human needs should be closely linked to create novel ways of doing things. In order to reach this aim, the economics literature has recognised how the capability to create new and valuable solutions by recombining existing components is strictly tied to search mechanisms (Weitzman 1998). Specifically, this kind of relationship between recombinant mechanisms and search is emphasised by evolutionary economists as a strategy to find sources of variety (Nelson and Winter 1982). Accordingly, 'innovation output can be increased by enhancing the recombinatory set that can be accessed by a firm' (Ahuja et al. 2008, p. 65). This means that searching becomes an important condition to create innovation, allowing firms to enlarge their knowledge base. In fact, a wide R&D effort radius is suggested to reduce the probability of technology opportunity exhaustion and to improve the mean rate of new knowledge development (Olsson and Frey 2002; Silverberg and Vespargen 2005; Van den Bergh 2008), as well as the creation of new breakthrough opportunities (Frenken et al. 2012). Therefore, firms are encouraged to innovate by seeking new components or new ways of using existing components (Galunic and Rodan 1998) across multiple and different landscapes (e.g. Fleming 2001; Li and Vanhaverbeke 2009). To this purpose, the literature has suggested searching across different industrial (e.g. Phene et al. 2006), organisational (e.g. Miller et al. 2007), and geographic contexts (e.g. Rosenkopf and Almeida 2003). However, despite the increasing importance of search within innovation processes, scholars have probed the difficulties coming from a broad search, such as managing an abundance of knowledge elements, due to limits in cognitive capabilities (e.g. Weitzman 1998), higher costs related to combinations between elements originating from dissimilar domains, and social refusal of certain combinations (Olson and Frey 2002).

The relationship between recombination and search can be better explained by borrowing from 'knowledge network' models. Indeed, focusing on the individual level, semantic memory models graphically depict the structure of memory by showing concepts as nodes and relations as links (Collins and Quillian 1969; Anderson and Bower 1973). Within this model, new knowledge creation occurs when new information is embedded within the network, and/or when the existing information within the network is recombined in a new way (Cohen and Levinthal 1990; Schilling and Phelps 2007). Specifically, cognitive psychology has recognised the associative nature of knowledge through which individuals link knowledge elements into memory after a phase of comprehension (Ellis 1965; Ericsson and Lehmann 1996). The role of associations has also been confirmed by using the science of

psychology of science in the investigation of the individual psychological processes that occur when novel ideas are generated in problem solving and scientific discovery (Darden 1980; Gentner 1982; Feist and Gorman 1998; Klahr and Simon 1999; Weisberg 1999). Indeed, the method of formulating hypotheses and experiments is grounded in knowledge recombinations, which are in turn developed after recognising familiar phenomena (Klahr and Simon 1999).

Nevertheless, individual knowledge is different from that of the firm. In fact, organisational knowledge is defined by the practices used to structure work and interactions among employees within a firm (March 1991; Kogut and Zander 1992, 1993). This peculiarity derives from the primary role of organisations in harnessing and coordinating the specialist knowledge of multiple individuals to produce goods and services (Grant 1996; Kogut and Zander 1993). Within this perspective, firms create new knowledge through the design and the subsequent implementation of new systems of coordination among employee activities (Kogut and Zander 1992, 1993; Zander and Kogut 1995), or through the acquisition and integration of external knowledge belonging to new employees (Simon 1991). Hence, the competitive advantage of a firm is mainly based on its combinative capabilities, through which people and other resources are coordinated (Grant 1991, 1996; Kogut and Zander 1992, 1993).

However, the successful absorption of new elements and the establishment of new links within existing knowledge elements rely on the scope and depth of firms' accumulated prior knowledge (Cohen and Levithal 1990). Indeed, the possession of a wide and deep knowledge base makes possible to recall, use, and combine knowledge elements in multiple and novel ways (Cohen and Levinthal 1990). Hence, absorptive capacity is critical in allowing firms to recognise the value of external knowledge, assimilate it, and apply it to commercial ends (Cohen and Levinthal 1990). However, the absorptive capacity of a firm depends on the absorptive capacities of its employees, and the communication structures between the external environment and the firm and among the members of the firm. Hence, firms need to reconfigure their resources to comprehend the changing external environments and markets in which they aim to be competitive, which calls for the development of dynamic capabilities (Teece and Pisano 1994; Teece et al. 1997; Galunic and Eisenhardt 2001; Zahra and George 2002; Zahra et al. 2006).

Based on the above discussion, innovation emerges as a process based on the recombination of knowledge elements, realised by integrating new elements or establishing new links. The identification, integration, and exploitation of new components, searched for

across multiple landscapes, is enabled by the absorptive capacity of inventing individuals and firms. In addition, these absorptive capacities are the antecedents of firms' dynamic capabilities, through which the achievement of the competitive advantage is reached despite changing market conditions. Thus, according to this perspective, recombinant search is the process through which individuals or firms identify new knowledge elements or new relationships and create new knowledge (Fleming 2001; Schilling and Green 2011). Nevertheless, an understanding of the main dynamics of recombinant search is still lacking, especially from a perspective that allows the analysis of innovation development at various levels (Gupta et al. 2007). Thereby, this paper aims to contribute to this issue by providing a review of the innovation management literature on recombination and search mechanisms across multiple levels, as well as by identifying relevant gaps and tracing directions for future research. Specifically, the review is conducted at two different levels of analysis—the inventor level and the firm level—distinguishing between approaches and strategies occurring both within and across firms' organisational boundaries.

Methodology

In the present section, we discuss the approach used to review the innovation management literature on recombination and search, in an attempt to recognise areas of convergence and suggest opportunities for future research. Specifically, this article follows the principles for systematic review suggested by Tranfield et al. (2003). The literature review process involves identification of publications of interest to researchers (data-gathering process), choice of relevant publications, and preparation of a research report. In order to provide a systematic, transparent, and replicable methodology, our review follows a number of stages (see also Meier 2011; Christoffersen 2013):

1) An initial list of keywords based on our prior experience was discussed with a review panel of three experienced academics in the field of innovation management and knowledge search strategy. This discussion resulted in 15 keywords[1].
2) Search strings were constructed with the keywords identified in Stage (1) and discussed with the review panel. Examples are: ['Search' and 'Knowledge'], ['Combination' and 'Knowledge'], ['Combination' and 'Innovation'], ['Search' and 'Innovation'], ['Integration' and 'Elements'].

[1] Keywords identified by the review panel: Acquisition, Combination, Components, Creation, Elements, Generation, Innovation, Integration, Knowledge, Recombinant, Recombination, Recombining, Recombine, Search, Source.

3) The review was limited to empirical peer-reviewed journal articles, leaving out books, book chapters, and conference proceedings. Furthermore, the review confined the search to high-quality journals in the management domain (Armstrong and Wilkinson 2007). We used the Social Science Citation Index (SSCI) to identify journals for inclusion. Specifically, as suggested by prior studies (e.g. Armstrong and Wilkinson 2007; Meier 2011; Christoffersen 2013), we included journals listed in the 'management' subject category of the ISI Web of Knowledge and having an impact factor greater than one (1.0) in 2012, assuring the inclusion of articles significantly influencing the academic debate. This selection yielded a list of 86 journals.
4) The EBSCO host (Business Source Premier) was the main database used for the literature search. Journals not available on EBSCO were searched manually via ScienceDirect and Google Scholar. The search strings developed in Stage (2) were used to search titles and abstracts. A total of 977 different articles were retrieved.
5) The 977 articles were reviewed following exclusion and inclusion criteria (Pittaway et al. 2004). These criteria (see Tables 1 and 2, respectively) were discussed with the review panel and subsequently adopted to analyse the initial list. The titles and the abstracts of the 977 articles were reviewed against the exclusion and inclusion criteria, thus leaving relevant 98 articles.

< Insert Table 1 about here >

< Insert Table 2 about here >

The articles adopted different research methodologies: 31 rely on qualitative methods (in-depth case study, historical case study, ethnographic study, field-based study, multiple case study) and 67 articles use quantitative methods (survey, analysis of archival data, social network analysis). The sample of articles resulting from this methodology was published from 1995 to 2013, but more than half of the studies (54%) were published after 2008, highlighting the emergent nature of the topic.

In addition, considering the journals in which the sample articles were published, it is interesting to notice how this topic is widespread in the innovation management literature. Indeed, the articles of our sample are available in 30 different journals, although most of them are found in top-quality outlets such as Research Policy, the Strategic Management Journal, Management Science, and the Journal of Product Innovation Management.

Furthermore, a number of additional articles cited in the reviewed studies are included as they contribute essential concepts necessary to make sense of the evidence base and structure the research findings. In the following, the two dimensions of inventor and firm (both within and across organisational boundaries) are used to group the discussion of the review results. First, the subsections are used to analyse and synthesise the key findings. Second, this analysis is used to derive promising directions for future research works in this line of inquiry.

Findings about Search and Recombination mechanisms

Inventors

The first theme of our review is the inventor because of the wide consensus in the literature on the centrality of the inventor's role in knowledge creation activities (e.g. Simon 1991; Grant 1996; Frenken et al. 2012). In particular, technological evolution depends on the links among knowledge elements explored by inventors in 'recombinant search' (Fleming and Sorenson 2001, 2004; Arthur 2007). Indeed, innovation derives from the thinking processes of inventors who recognise the associations among knowledge elements they encounter in the search process and their cumulated knowledge (Klahr and Simon 1999).

First, inventors exploit their knowledge by searching among components and combinations they have experienced (e.g. Nelson and Winter 1982; Vincenti 1990; Fleming 2001; Fleming and Sorenson 2004; Cillo and Verona 2008). Such a local approach is due both to cognitive limits, because of which people concentrate on particular subjects, and social processes, which define subjects and boundaries inhibiting new lines of invention (March and Simon 1958; Nelson and Winter 1982; Fleming 2001). Hence, new combinations are the result of a local search process through which inventors, starting from familiar combinations, alter one component at a time and replace it with a different one (Vincenti 1990; Fleming and Sorenson 2004). One practical example is when a pastry chef mixes previously used dyes in new proportions to create a novel frosting colour (Fleming 2001). A generalisation of this approach is product modularisation, which consists of de-coupling components to reduce the effective interdependence between them. Thus, modularisation constrains improvements within previously considered and tested interfaces (Fleming and Sorenson 2001, 2004). However, working with a particular and limited set of components may exhaust the possibilities in terms of developing useful combinations (March 1991; Fleming 2001;

Majchrzak et al. 2004; Kalogerakis et al. 2010). A practical method to enlarge the set of knowledge components is provided by community involvement, as in the case of software developers working with fully tested algorithms, single lines of code, and components (Knight and Dunn 1998). In this kind of open knowledge repository, inventors are interested in identifying links with unknown components rather than discovering single components, and the community provides stable and documented interfaces. Indeed, a suitable and available interface allows developers to integrate components in the software without understanding the technical inner workings (Haefliger et al. 2008). Nevertheless, the community involvement represents access to a repository set of knowledge pertaining to the same knowledge domain as that of the inventor. In the end, modularisation and community provide the instruments to make the innovative process easier, more assured, and probably faster, even if this often decreases the likelihood of a successful breakthrough (Fleming and Sorenson 2001, 2004; Haefliger et al. 2008). In fact, inventors who work with modules or with the components provided in a community do not know or poorly understand how components interact each other (Simon 1973; Sanchez and Mahoney 1996; Fleming and Sorenson 2001). This lack of knowledge about the overall system of links and knowledge leads to the creation of mainly incremental improvements (Fleming and Sorenson 2001, 2004). In conclusion, inventors develop knowledge combinations by adopting an initial local search within their own sets of knowledge components that could be extended to new and different elements belonging to the same domain. The literature has identified two solutions to implement this kind of local recombinant search: modularisation and community involvement. The former is applied to improve a combination by modifying known components without altering links. The latter, however, is adopted to combine unknown components using links suggested by members of the same knowledge community.

However, innovative solutions are often created by combinations of knowledge elements coming from different and seemingly unrelated domains (Schon 1993; Hargadon and Sutton 1997; Fleming and Sorenson 2001; Fleming 2002; Hargadon 2002; Lettl et al. 2006; Taylor and Greve 2006; Kalogerakis et al. 2010; Schoenmakers and Duysters 2010; Schilling and Green 2011). The mechanism through which these combinations become possible is defined as analogy (Reeves and Weisberg 1993; Keane 1988; Schon 1993; Hargadon and Sutton 1997; Hargadon 2002; Kalogerakis et al. 2010). It consists of borrowing familiar components in a domain (the base) to solve a problem at hand (the target). Hargadon (2002) has reported the example of a designer who recognised the usefulness of splints in a

new basketball shoe in order to protect feet. Another case is the Swiss neurosurgeon Professor Reinhard from the University of Basel, who was a clockmaker before beginning his career in the medical field. Specifically, he was able to develop solutions for navigation systems in neurosurgery by linking his knowledge of miniaturisation in the design of complex clockwork devices to solve novel surgical problems (Lettl et al. 2006). The distance between the starting domain of the basic elements and the final application of the solution may be expressed by using two main dimensions: transfer distance and transfer content. In particular, the former describes the distance between the base and the target domains focusing on the field of application. Transfer content, on the other hand, specifies the type of elements that were transferred from the base domain to the target problem (Kalogerakis et al. 2010). If analogies blend elements belonging to distant domains, this generates atypical links. For example, the dyad sand and aluminium, currently the most common basic materials of semiconductors, would have been unthinkable to an electrical engineer of the 1940s (Fleming and Sorenson 2001). A further case is represented by the combination of resistor, ink, and semiconductor manufacturing techniques, which radically changed the printing industry with the creation of ink-jet printers in the 1980s (Fleming 2002). Thus, the establishment of atypical links is very interesting because it may generate a radical change in the individual's perception of distance between other elements associated with new, combined ideas. In fact, atypical links bring distant components into close proximity, and this dramatic decrease in path length between formerly distant components may induce inventors to try relationships between other elements of new related domains. Thereby, establishing atypical links may generate numerous new solutions and increase the likelihood of developing valuable innovations. This phenomenon suggests that breakthrough innovation is more likely to occur through the combination of disparate and unrelated ideas (Schoenmakers and Duysters 2010; Schilling and Green 2011). Indeed, a growing body of literature has underlined the importance of searching across more distant knowledge domains to increase combinatorial possibilities (Fleming and Sorenson 2001) and overcome the tendency to address problems within a familiar set of knowledge elements (Levinthal and March 1993; Perkins 1995; Gavetti and Levinthal 2000; Ahuja and Lampert 2001).

Having achieved comprehension of how distant search may influence the generation of atypical links and breakthrough innovation, we now explain the solutions found in the innovation management literature to sustain inventors' search effort in distant domains. First, Marcian E. 'Ted' Hoff, the inventor of the microprocessor, suggested 'reading as much as

possible and … keep[ing] up with everything that's happening'. This mechanism, defined as 'net casting', permits the gathering of information pertaining not only to the domain of direct interest but also to areas outside the specific domain (Maggitti et al. 2013). A former implementer of this approach was Josiah Wedgwood, an English potter, who brought many kinds of innovation to his industry by exploiting a range of weak and strong ties for reaching new and distant ideas and markets. He belonged to many societies and clubs, and searched widely for new ideas amongst artists, craftsmen, scientists, politicians, and aristocrats. He was also a friend of James Watt and Matthew Boulton, the developers of the steam engine, a technology Wedgwood introduced into the pottery industry (Dodgson 2011). Another system inventors may adopt to access different knowledge elements and combine them is involvement in a team (Taylor and Greve 2006; Perretti and Negro 2007; Singh and Fleming 2010; Bercovitz and Feldman 2011; Maggitti et al. 2013). In fact, as affirmed by Bercovitz and Feldman (2011, p. 92), 'innovation is increasingly becoming a team sport'. Furthermore, technological inventions developed by inventors involved in a team are more likely to become breakthroughs than those generated by lone inventors (Singh and Fleming 2010). However, the composition of teams plays a critical role in the success of the resulting inventions. Raymond Kurzweil (the inventor of the electronic piano/synthesiser) observed that the projects in which he was engaged increasingly involved linguistics, signal processing experts, very large scale integration designers, psycho-acoustic experts, speech scientists, computer scientists, human factor designers, and experts in artificial intelligence and pattern recognition (Maggitti et al. 2013). This observation confirms that teams with multiple areas of expertise and competencies are more likely to develop innovative solutions (Taylor and Greve 2006). The positive effect due to knowledge elements coming from many experiences is also underlined by the gains derived from the inclusion of new members. Specifically, the employment of newcomers has been proven to allow genre innovation (Perretti and Negro 2007), and groups integrating scientific and technological approaches are more likely to generate a positive outcome in terms of patenting, licensing, and royalty performance (Bercovitz and Feldman 2011). However, combinations of diverse knowledge elements originating from multiple persons with different backgrounds remain inherently difficult. Following this last consideration, knowledge combinations may occur more easily when a team has past common work experience (Taylor and Greve 2006; Bercovitz and Feldman 2011). Nonetheless, a successful team needs to collect and recombine not only different but also complementary knowledge elements as components that are both related and diverse, such as design and manufacturing or retailing knowledge (e.g. Harryson et al. 1991, 2001;

Abecassis-Moedas and Mahmoud-Jouini 2008). Specifically, it has been demonstrated that complementarity between manufacturers and designers determines cost reduction and quality improvement, while knowledge complementarity between retailers and designers leads to a better fit with market needs (Abecassis-Moedas and Mahmoud-Jouini 2008).

Nevertheless, when inventors manage different and unknown components, they have to face the problem of finding the right and most promising combination. To reach this purpose, they have to understand how components interact. In fact, a change to any component, even if it seems small and less influential, can impact other components and completely alter the behaviour of the resulting final artefact (Ulrich 1995; Baldwin and Clark 2000; Fleming and Sorenson 2001). For example, if the amount of impurity doped in silicon changes by less than one per cent, the resistance at 30°C can change by a factor of 24,100 (Fleming and Sorenson 2001). In this case, modification of the impurity component implies that the device based on silicon resistance does not work effectively. Therefore, as interdependence among elements increases, inventors must delve deeper into the internal workings of each 'black box', represented by the behaviour of a single component in a specific combination. A scientific background may contribute to this full understanding of components' underlying properties (Fleming and Sorenson 2004, Gruber et al. 2012). Indeed, individuals with a doctoral degree or with scientific work experiences have been demonstrated to have the capability to successfully combine knowledge elements from distant domains (Gruber et al. 2012). Furthermore, science is suggested as a useful support to recombine highly coupled components by providing inventors with the equivalent of a map indicating the proper search directions (Fleming and Sorenson 2004).

Firms

In the following section, we shift our attention from the inventor level to the firm level of analysis and, specifically, how firms organise and structure the process of recombinant search. Specifically, we discuss how firms organise themselves in the attempt to search for and recombine knowledge resources to innovate (Kogut and Zander 1992, 1993). Accordingly, we divide our analysis into two sections: the first explores how recombinations and search mechanisms occur within firm organisational boundaries, while the second identifies the principal literature findings in terms of the solutions implemented by firms to search across their organisational boundaries and recombine components acquired from the external environment.

Within Firms Organizational Boundaries

The choice to analyse recombinant mechanisms within firm boundaries is related to the strong influence of firms' internal organisation on both the quantity and quality of their innovative outcomes (Lengnick-Hall 1992; Lefebvre et al. 1997; Zahra and Nielsen 2002; Argyres and Silverman 2004; Jansen et al. 2006; Terziovski 2010). Thus, firms' choices for internal organisation represent powerful strategic levers for top management and have become a key topic in the research on the strategic management of innovation (Gulati and Puranam 2009). The most important factors firms have to manage to internally support recombinations are represented by social capital, corporate organisation, and the tacit nature of knowledge.

In fact, within firms, social capital is increasingly becoming viewed as asset required to access knowledge (Inkpen and Tsang 2005). Social capital explains the better performance of people that are better connected with others (Burt 2005). It is the value from personal networks based on socialisation, and it has been proven to be a popular and powerful mechanism to transfer knowledge (Huggins 2010). Nevertheless, social capital is very difficult to manage (Huggins 2010), and this section analyses how recombinant literature has addressed this issue. Essentially, scholars have underlined the necessity of building interactions among an organisation's members (e.g., Zander and Kogut 1995; Harryson 1997; Fleming 2002; Sheremata 2002; Cillo and Verona 2008; Carmeli and Azeroual 2009; Tran 2010). The main advantage is the access to various knowledge elements, creative ideas, and accurate information without obstacles to free flows of information (Reagans and McEvil 2003). This allows firms to increase knowledge stores, generate a large number of new combinations, and be more likely to create valuable products (Fleming 2002; Sheremata 2002). In addition, high-quality ties formed and maintained with members of different units ease knowledge sharing to identify gaps and new and improved ways to combine knowledge (Harryson 1997; Carmeli and Azeroual 2009; Huggins 2010). Indeed, any unit that encounters a problem starts to search for solutions within a de facto subgroup constituting employees that usually exchange knowledge among themselves (Monteiro et al. 2008). Nevertheless, these subgroups can be risky because they can pursue autonomous interests (Kieser and Koch 2008). Furthermore, if a unit remains alienated from these subgroups, it does not have access to elements of other members of the firm or to information and news about opportunities and obstacles (Monteiro et al. 2008). The likelihood of this kind of risk is higher for incumbent firms. Indeed, long-time employees have demonstrated the tendency to interact only within a limited group of colleagues with whom they have shared most of their experience during their

working life (Borgatti and Cross 2003; Monteiro et al. 2008). Thus, to counteract this tendency, managers have to foster socialisation among all of an organisation's members (Zander and Kogut 1995; Sorenson et al. 2006) by promoting informal face-to-face meetings between employees from different departments, such as joint coffee and lunch breaks and periodical informal meetings (Schulze and Hoegl 2008). Social capital is studied in the recombinant search literature because of its inherent capacity to provide different knowledge elements from various domains and, hence, to make the development of analogies easier (Hargadon and Sutton 1997; Hargadon 2002).

Nevertheless, firms cannot delegate all the efforts for knowledge search and recombination to informal initiatives of socialisation among employees. In fact, firms need to favour connections and relationships among their members (Garud et al. 2011). An effective solution to stimulate the integration of multiple knowledge elements is represented by corporate reconfiguration, which recombines people holding different types of knowledge elements into new organisational units (De Boer et al. 1999; Galunic and Eisenhardt 2001; Helfat and Eisenhardt 2004; Karim 2006, 2009; Kieser and Koch 2008). This type of mechanism has the advantage of creating a platform that may generate new product combinations for new markets (De Boer et al. 1999; Galunic and Eisenhardt 2001; Kieser and Koch 2008). However, a reconfiguration that really enhances innovation is the result of a complex learning process. Indeed, firms need to build significant experience to successfully reorganise their resources (Karim 2006, 2009). More common formal efforts to connect employees with people and technologies distributed inside firms are cross-functional teams and personnel rotation between platforms and business units (Harryson 1997; Hargadon 2002; Garud et al. 2011). Thereby, firms may form inter-functional teams or may rotate people between platforms and business units to provide a bridge between technologies and expertise (Harryson 1997; Garud et al. 2011). A further proposal to simplify the connections between people and experiences involves the physical proximity of various labs in the same geographical place. Canon Inc.'s serendipitous invention of Endiro demonstrated how close physical proximity of different laboratories increases the likelihood that employees will develop a new, successful combination (Allen 1977; Fleming 2002). In addition, multinational companies have to build connections across their R&D units located in different countries to effectively recombine various knowledge elements (Singh 2008). Indeed, multinational companies locate their R&D units in many countries to create a continuous link with different local institutional environments, local markets, and technological opportunities (Gerybadze and Reger 1999; Tripsas 1997; Ahuja and Katila 2004; Persaud 2005; Zander

2007). However, the mechanisms to integrate knowledge across these dispersed R&D sites are complex and often difficult to realise, which may risk a reduction of the benefits gained from access to a global pool of knowledge. Inter-personal ties among employees across different regions may help to solve this problem (Singh 2008). Moreover, the effort to create a configuration that combines different experiences has to consider the complementarity of knowledge components. In fact, it has been demonstrated that the value of singular knowledge element is influenced by how the various elements are combined (Tzabbar et al. 2008). Specifically, a radical result is facilitated by the integration of employees with general qualifications and scientists with heterogeneous know-how. An incremental innovative result, however, requires scientists with homogeneous knowledge and a workforce specialised in managing specific knowledge (Hermann and Peine 2011). Finally, other scholars have underlined that effective cooperation and knowledge sharing among units and individuals may be promoted by new reward systems. Indeed, it is necessary to evaluate informal reputation among colleagues through formal peer reviews, which underline employees' ability to collaborate and interact with colleagues to find solutions. Indeed, this attitude is fundamental for firms that aim to develop an innovation process based on the recombination of elements from different domains and to encourage idea and insight sharing (Hargadon and Sutton 1997; Hargadon 2002). On the basis of the above reasoning, this section contributes to confirm that firms' innovative capacity is strictly determined by internal systems of coordination and integration (Adams et al. 2006).

When firms configure the connections among their members with the purpose of stimulating collaborations and teamwork, they primarily have to stimulate the flows and exchanges of tacit knowledge (Reed and DeFilippi 1990; Kogut and Zander 1993; Zander and Kogut 1995; Amin and Cohendet 2004; Sammarra and Biggiero 2008). Tacitness is particularly problematic when experiences and domains are distant, increasing the difficulty of understanding and using knowledge effectively (Polanyi 1966). This kind of problem may be solved by solutions like 'Work-Out', in which General Electric created an open, collaborative workplace in which everyone's opinions are welcome, and each employee participates in the innovation process (Ulrich et al. 2002). Another case is represented by the '15 per cent rule' proposed by The 3M Company. Specifically, the company encourages employees to devote 15% of their work time to a preferred research project that is different from their usual business. This volunteer involvement allows employees to get deeper into new domains and to identify new applications or extensions (Garud et al. 2011). Furthermore, tacitness is generally a distinctive feature of more recent knowledge that has not yet started

the process of codification (Nonaka and Takeuchi 1995; Lam 2000; Nonaka et al. 2000). Therefore, the integration of this knowledge in new recombinations is more costly and difficult (Katila 2002). In fact, seminal works have proven that firms tend to reuse and exploit their prior knowledge elements to solve new problems (Katila and Ahuja 2002), and to cut costs and time to market (Ettlie and Kubarek 2008). Moreover, mature and well-understood knowledge elements are fundamental bricks with which to create radical inventions (Schoenmakers and Duysters 2010), since they offer greater reliability and may be revitalised by the exploitation of emergent technological solutions (Ahuja and Lampert 2001; Nerkar 2003; Messeni Petruzzelli and Savino 2012). Old knowledge that is distant from the firm's actual industry plays an especially positive role in value creation (Messeni Petruzzelli et al. 2012). Nevertheless, excessive age may also hamper the development of innovative results (Katila 2002), due to the risk of obsolescence. The difficulty of managing tacit knowledge, especially when the knowledge is recent, is thus confirmed. To overcome this situation, many firms are investing effort in the re-use of old internal knowledge.

Beyond Firms Organizational Boundaries

In this section, the study enlarges its focus beyond firm organisational boundaries because knowledge, as an enabler of innovation, is often dispersed outside of the focal firm (Von Hippel 1988; Bogers and West 2012). Accordingly, importing new external ideas is deemed an effective approach to multiply the number and variety of building blocks for innovation (Rigby and Zook 2002; Nerkar 2003; Laursen and Salter 2006; Fabrizio 2009; Chen et al. 2011), as has been discussed in the open innovation paradigm (Chesbrough 2003). In fact, firms are increasingly combining their internal innovative efforts with external knowledge acquisition activities (von Hippel 1988; Teece 1996; Cassiman and Veugelers 2006; Beamish and Lupton 2009; Lichtenthaler 2011). The effects of this kind of recombinant approach are various, such as the adaptation to market needs (Rosenkopf and Nerkar 2001; Salvato 2003; Belenzon 2011), market acceptance (Bonesso et al. 2011), and the reduction of costs and time for product development (Gronlund et al. 2010). Volvo Car Corporation's development of hybrid electric vehicles is an exemplar case. This carmaker, despite limited internal resources, developed this radical technology not only by exploiting internal technical solutions but also—in fact, especially—thanks to the integration of technological solutions proposed by suppliers (Pohl and Elmquist 2010). The model of open innovation, in which knowledge is sought across organisational boundaries to realise new recombinations with internal knowledge elements, has been adopted in a variety of industries including copiers, computers,

disk drives, semiconductors, telecommunications equipment, pharmaceuticals, biotechnology, and even military weapons and communications systems (Chesbrough 2003). In line with this paradigm, Procter & Gamble has developed a 'connect and develop' strategy with the aim of profiting from the use of ideas from millions of worldwide external inventors. Similarly, Air Products and Chemicals, Inc. has adopted the 'identify and accelerate' strategy to make the innovation processes faster. This strategy is based on tools such as external partnering, global R&D in-sourcing, Internet-based knowledge provision, and formal mechanisms to evaluate external ideas (Gronlund et al. 2010). Nevertheless, a recent study (Fixson and Lee 2012) showed that explorations across organisational boundaries provide better results when the industry is in the 'post-take-off' stage. In other words, firms may create successful products by searching beyond their boundaries only after the dominant design has been accepted within the industry.

After discussing the relevance of external search, it is interesting to investigate what firms tend to search for across the external environment. Makri and Lane (2007) demonstrated that firms are primarily interested in searching for technological and scientific knowledge since these increase their capacity to introduce new products to the market (Katila and Ahuja 2002). However, to recombine different types of knowledge effectively, firms need to explore at a small technological distance, thus being able to understand and integrate the heterogeneous knowledge components (Gilsing et al. 2008). Nevertheless, when firms search too close to their knowledge bases, knowledge redundancy (Gold et al. 2001; Padula 2008) may reduce their likelihood of coming up with novel combinations (Sapienza et al. 2004), necessitating a trade-off. The decision to search for technological solutions externally is principally determined by the appropriation regime, since stronger systems based on legal regulations, complexity, secrecy, or lead-time on competitors may reduce the recourse to external technology sources, leading firms to conduct internal search and exploration (e.g. Veugelers and Cassiman 1999). Shifting the attention from technological to scientific knowledge, the recombination of scientific knowledge elements seems to be particularly beneficial in the development of radical innovations (Paananen 2009) and to achieve a long-term and sustainable competitive advantage (Makri and Lane 2007). Nevertheless, invention outcomes have proven to have higher levels of quality and novelty when firms search for, identify, acquire, and recombine both scientific and technological knowledge, suggesting the complementary roles of these two knowledge types (e.g., Makri et al. 2010). Therefore, the main types of knowledge firms search for beyond their organisational boundaries are mainly

represented by technology and science. In addition, better results emerge when technology and science are both exploited and when search occurs at a small technological distance.

A further interesting issue is the choice of external sources from which knowledge elements should be acquired, such as customers, suppliers, competitors, universities, and private research institutes (Knudsen 2007; Sofka and Grimpe 2010; Lichtenthaler 2011). Suggestions about the criteria used to identify useful sources are necessary because the locus of innovation for many industries is now situated beyond the confines of their central R&D laboratories (Chesbrough 2003). A study by Darr and Kurtzberg (2000) underlined strategy similarity as the most important driver in selecting a source, which may offer appropriate knowledge elements. Specifically, studies have revealed R&D collaboration, market-based transactions, and the modification of internal strategies as conditions required to identify external knowledge (e.g. Fosfuri and Tribò 2008). However, the literature has found that the fitness of a specific external source depends not only on its intrinsic features but also on the characteristics of the industries and national innovation systems within which it operates (Laursen and Salter 2004; Fabrizio 2009; Grimpe and Sofka 2009; Sofka and Grimpe 2010; Berkers and Geels 2011). Many studies have regarded universities and research institutions as a critical source of external knowledge, although results conflict (Laursen and Salter 2004; Fabrizio 2009; Grimpe and Sofka 2009; Cosh and Huges 2010; Sofka and Grimpe 2010; Berkers and Geels 2011; Chen et al. 2011). For example, Grimpe and Sofka (2009) have proved that firms in high- and medium-technology industries prefer universities. This is based on the fact that academic knowledge does not tend to successfully complement any other knowledge elements, making it more difficult to combine and use in the innovation process (Cosh and Huges 2010). Hence, the contribution of universities is especially relevant in technologically advanced nations (Sofka and Grimpe 2010) and for firms with 'structural' attributes, such as significant investments in internal R&D (Laursen and Salter 2004; Fabrizio 2009). More recently, Berkers and Geels (2011) argued that universities are particularly important in sectors, such as agriculture, house building, manufacturing, and financial and commercial services. Indeed, they found that when competition is cost based and sectors consist of many small firms with weak R&D and engineering capabilities, universities can carry out formal R&D activities and the firms perform the final product assembling and implementation. In addition to universities, the literature has focused on customers' efficiency as a source of knowledge (Grimpe and Sofka 2009; Tolstoy 2009; Sofka and Grimpe 2010). Customers are an essential reference for those firms that generally pursue expansion in numerous foreign markets (Tolstoy 2009), for firms in low- and medium-technology

industries (Grimpe and Sofka 2009), and for firms with internal R&D activities (Sofka and Grimpe 2010). Suppliers are another potential source of external knowledge (Li and Vanhaverbeke 2009; Chen et al. 2011). In fact, innovating firms may search for suppliers that belong to very different industries with the aim of uncovering new and complementary knowledge elements and recombining them into pioneering innovations (Li and Vanhaverbeke 2009). Finally, the literature has revealed that it is possible to learn which strategic and technological direction to follow for new product introduction by observing competitors' behaviour (Veugelers and Cassiman 1999; Katila and Chen 2008).

A particular area of interest in the large arena of external knowledge search is how organisations develop ties with external sources in order to access to new stocks of knowledge. Employee mobility is one instrument that allows firms to recombine external knowledge elements. This individual-level phenomenon involves the one-time transplant, from one firm to another, of a particular employee's set of skills, knowledge, and productive effort (Almeida and Kogut 1999; Song et al. 2001; Rosenkopf and Almeida 2003). A more structured solution involves establishing alliances which facilitate access to knowledge that would otherwise be inaccessible (Mowery et al. 1996, 1998; Powell et al. 1996; Stuart and Podolny 1996). Specifically, alliances increase the chances of recombinations among mature and emergent knowledge elements (Schoenmakers and Duysters 2010). Moreover, it is necessary to establish alliances not only with partners in turn connected with each other (cohesive alliance) but also with partners totally disconnected from each other (sparse alliance) (Padula 2008). Indeed, sparseness enables firms to achieve richness in terms of diverse perspectives, skills, and resources (Reagans and McEvil 2003). Conversely, densely connected partners provide knowledge elements to implement and generate value around the insights uncovered by shortcut relationships (Padula 2008). A network of strategic communities can be seen as an attempt to integrate cohesiveness and sparseness (Kodama 2005). Specifically, a community is a team composed of members of different organisational units, suppliers, customers, and allied firms. The knowledge elements that emerge in a specific community are shared and then diffused among the other communities with the aim of finding better solutions for new products or services (Kodama 1999; Storck and Patricia 2000; Kodama 2005). However, an effective collaboration with different external sources has to build trust and mutuality (Batenburg and Rutten 2003; Knudsen 2007; Wu 2008). Accordingly, rotating leadership is a managerial solution implemented by large and established firms to facilitate trust and mutuality among partners (Davis and Eisenhardt 2011). Specifically, rotating leadership requires that partners alternate decision control

between unilateral and subsequent phases. The first advantage is that each partner, during its control period, can access partners' complementary knowledge elements. At the same time, non-leading partners are motivated to share their knowledge because of their awareness that they will obtain similar benefits during their control rounds (Davis and Eisenhardt 2011). Finally, significant focus emerges not only on the methods used to access the knowledge of external sources but also on the solutions required to build a trusting relationship with external partners.

Another issue scholars have investigated regards the location of external sources. A geographically distant source of knowledge may be very useful to develop successful new recombinations, since this allows the technological base to be enlarged with a variety of knowledge elements (Kriauciunas and Kale 2006; Phene et al. 2006). Nevertheless, knowledge elements acquired from distant places may lead to successful changes in products and organisations only if these elements come from new markets in which firms plan to introduce their products (Kriauciunas and Kale 2006). Spatial proximity often characterises the relationships firms establish, especially at the beginning of their life (Cantù 2010). Afterwards, geographic search strategy is influenced by location munificence (Coombs et al. 2009). This phenomenon can be explained by looking at New Zealand, a country in which firms from very different industries built their success without reliance on local knowledge sources. The factors that led firms towards a rapid internationalisation search strategy were the lack of intra-sectoral firms at the moment of start-up and the high level of customisation required to satisfy the needs of geographically distant customers (Davenport 2005). Nevertheless, Li and Vanhaverbeke (2009) overcame the concept of geographical proximity and stressed the issue of similarity with respect to language, institutional rules, and culture. The choice of suppliers from similar countries seems to favour the generation of pioneering innovations because members of firms from similar countries can more easily exchange the knowledge elements to be recombined. Although the international dimension of knowledge search involves foreign partners (e.g., Muethel and Hoegl 2010), further analysis is needed because cultural issues have been largely neglected thus far (Lichtentaler 2011).

The number of different sources of external knowledge is another important factor firms need to take into account. Indeed, innovative firms tend to employ a broad range of external knowledge sources to innovate (Laursen and Salter 2006; Belussi et al. 2010; Chiang and Hung 2010). However, knowledge elements coming from multiple partners with diverse technological, scientific, or market orientations may negatively influence the development of valuable products (Knudsen 2007; Wang and Li 2008; Capaldo and Messeni Petruzzelli

2011). Nevertheless, the advantage of drawing from a limited number of sources is controversial. Laursen and Salter (2006) found a significant association with the development of radical innovations, while Chiang and Hung (2010) proved that relying upon few external sources mainly influences the creation of incremental innovations. On the basis of these results, we can argue that both the scope and the depth of external search processes play important roles in innovativeness, even though their actual influence requires further and more exhaustive investigations.

Discussion, Future Directions, and Conclusion

This paper contributes to the innovation management literature by reviewing research works that address the recombinant search approach to developing innovation. We provide an in-depth analysis of the empirical results grouped by two main dimensions: the inventor and the firm. Discussion at the firm level presents recombinations and search mechanisms both within and outside of organisational boundaries. Building on this framework review, we identified central issues and spot research gaps.

Firstly, in our systematic review, we found 17 papers which focus on inventors, while 81 focus on firms. Hence, the recombinant approach is applied more frequently to investigate how firms organise themselves to innovate. In the innovation management literature, the recombinant view has been adopted less often to explain the inventive processes of individuals. Instead, a great deal of research on inventors exists in different literature fields such as creativity (e.g., Rhodes 1961; Amabile 1983; Audia and Gonlalo 2007) and psychology (e.g., Simon 1977; Csikszentmihly 2009). Therefore, it could be useful to analyse the inventive processes of individuals using a recombinant perspective that integrates management literature with other streams. In the following, for each level of analysis, we summarise the main findings and trace a number of directions for future research.

Inventors

A wide consensus has been developed in the literature around the usefulness of combining elements from seemingly unrelated domains for inventors' recombinant process of innovation (Schon 1993; Hargadon and Sutton 1997; Fleming and Sorenson 2001; Fleming 2002; Hargadon 2002; Lettl et al. 2006; Taylor and Greve 2006; Kalogerakis et al. 2010; Schoenmakers and Duysters 2010; Schilling and Green 2011). This result confirms and extends prior research about the need to increase cross-fertilisation of ideas across different subject areas (Gopalakrishnan and Damanpour 1997). The attention given to a variety of

knowledge elements is also motivated by the opportunity to implement an explorative search and create breakthrough solutions effectively (March 1992; Fleming 2002; Schoenmakers and Duysters 2010; Schilling and Green 2011). In addition, the recombinant literature has recognised analogy as the main approach for combining distant knowledge elements (Reeves and Weisberg 1993; Keane 1988; Schon 1993; Hargadon and Sutton 1997; Hargadon 2002; Lettl et al. 2006; Kalogerakis et al. 2010).

However, in order to create analogies, it is necessary to enlarge inventors' knowledge element set. The involvement of inventors in teams is the most promising mechanism through which to access different knowledge elements and combine them (Taylor and Greve 2006; Perretti and Negro 2007; Abecassis-Moedas and Mahmoud-Jouini 2008; Singh and Fleming 2010; Bercovitz and Feldman 2011; Maggitti et al. 2013). However, team composition continues to attract further interest in the literature. Indeed, there are many unresolved questions about the acceptable degree of diversity in a team (Taylor and Greve 2006; Perretti and Negro 2007), about the complementarity of knowledge (Abecassis-Moedas and Mahmoud-Jouini 2008; Bercovitz and Feldman 2011), and about the routines that favour integration (Taylor and Greve 2006; Bercovitz and Feldman 2011). In fact, the optimum number of members remains unclear, as does the breadth of competences and experiences that is more likely to generate successful innovative outputs. Furthermore, the literature has found that members generally create spontaneous routines by working together, but it lacks analysis of how to improve this specific process. The results lack specific industry contextualisation, which calls for deeper investigations. Moreover, our analysis reveals that the literature has largely discussed the role of lone inventors (Singh and Fleming 2010; Dodgson 2011; Maggitti et al. 2013), although the influence of personal traits such as the kind of prior work and school experiences, psychological characteristics, hobbies, and private life on the likelihood of developing breakthroughs needs to be further explored. Finally, it could be also interesting to understand which social, cultural, and economic contexts favour the emergence of successful lone inventors.

Within Firms Organizational Boundaries

By reviewing empirical evidence at the firm level, previous studies have analysed how firms organise themselves to allow their employees to access a significant number of different knowledge elements. For this purpose, the literature has widely proposed the development of social capital and the implementation of ad hoc corporate configurations.

Social capital, consisting of the knowledge gained from personal social networks, is one of the most effective mechanisms to sustain knowledge sharing among firms' members (Sheremata 2002; Reagans and McEvil 2003; Inkpen and Tsang 2005; Schulze and Hoegl 2008). The main advantage is simplifying the access to large quantities of knowledge elements, creative ideas, and accurate information (Reagans and McEvil 2003). This result is in line with the theory asserting that social relationships play a fundamental role in favouring knowledge circulation and management within firms (Huggins 2010). However, the few activities suggested to promote socialisation are joint coffee and lunch breaks, and periodical informal meetings (Schulze and Hoegl 2008). Therefore, more structured research about new and attractive methods of socialisation among employees based, for example, on the application of art and entertainment principles is required.

Despite the role of personal socialisation, firms need to create more formal relationships and connections among members. Potential solutions are new corporate reconfigurations through which new business units are created with people holding different types of knowledge (De Boer et al. 1999; Galunic and Eisenhardt 2001; Helfat and Eisenhardt 2004; Karim 2006, 2009; Kieser and Koch 2008). Multinational corporations, for instance, can increase their recombinant potential by locating units in different countries (Tripsas 1997; Zander 1997; Persaud 2005). The main purpose of this action is the generation of new product combinations for new markets (De Boer et al. 1999; Galunic and Eisenhardt 2001; Kieser and Koch 2008). The tight relationship between corporate configuration and innovation is consistent with previous literature reviews on innovation management (e.g., Klein and Sorra 1996; Tidd 2001). In fact, our findings support a stronger role for internal organisation in sustaining the generation and translation of ideas into marketable products (e.g. Rothwell et al. 1974; Adams et al. 2006). Nevertheless, the success of an organisational reconfiguration is largely due to the firm's experience (Karim 2006, 2009). Hence, we suggest that more attention be given to solutions that allow firms to reconfigure their internal resources more easily and effectively. In addition, future works could focus on identifying the organisational configurations most suited to specific technological and market environments. Regarding the dislocation of units abroad, analysis of the role of employees operating in these dislocated units is lacking. One unresolved issue, in fact, regards the right balance between employees coming from the parent and subsidiary countries to fully exploit their diverse competencies and successfully recombine them. Finally, the analysis of corporate reconfigurations has mainly focused on U.S. multinational companies. Therefore, we suggest there is an opportunity to enlarge the focus of analysis to examine the major emerging national

economies, as Brazil, Russia, India, China and South Africa (the BRICS group) in an attempt to uncover their recombinant dynamics.

Within firm boundaries, a large amount of knowledge transferred among members, especially through the organisational solutions presented above, is tacit (Kogut and Zander 1993; Reed and DeFilippi 1990; Zander and Kogut 1995; Amin and Cohendet 2004; Sammarra and Biggiero 2008). Some works have provided solutions to better integrate tacit knowledge, but these are highly company specific (Ulrich et al. 2002; Garud et al. 2011). Nevertheless, tacitness is mainly a characteristic of recent knowledge which has not yet started the process of codification (Nonaka and Takeuchi 1995, Nonaka et al. 2000). Moreover, tacit new knowledge is difficult to recombine, especially when it comes from different and distant domains. Therefore, the integration of this knowledge in new recombinations is more costly and difficult (Katila 2002). In fact, seminal works have proven that firms tend to reuse and exploit their prior knowledge components to different degrees (Ahuja and Lampert 2001; Katila 2002; Nerkar 2003; Ettlie and Kubarek 2008; Messeni Petruzzelli and Savino 2012). This result confirms the increasing managerial attention on solutions that allow the re-use of knowledge over time (Cusumano and Nobeoka 1992; Corso et al. 2011). Regarding the search and recombination of knowledge over time, our analysis shows that it is requires greater qualification of the maturity of knowledge elements, for example, by identifying the contingent conditions that enhance or reduce their contribution to successful innovation. In addition, studies on knowledge search over time are generally based only on high-technology sectors; few works have underlined the practice of searching in the past within less technology-intensive industries, such as creative and cultural sectors (see, e.g. Cillo and Verona 2008; Messeni Petruzzelli and Savino 2012). Finally, it is interesting to point out that most of these results have emerged from the analysis conducted on large organisations. Therefore, future research is needed to identify how small and medium-sized enterprises may exploit and successfully recombine their own old knowledge.

Beyond Firms Organizational Boundaries

Shifting the attention beyond firms' organisational boundaries, scholars have identified more suitable external sources of knowledge. This effort is justified by prior results demonstrating that companies should build relationships with external sources of knowledge to foster knowledge creation (e.g. Corso et al. 2001). In addition, the identification of external sources is consequent to the change in the paradigm of innovation development, which is shifting towards the so-called open approach (Chesbrough 2003). Indeed, actual innovative processes are devoted to acquiring knowledge that is often dispersed beyond firms'

boundaries (e.g. von Hippel 1988; Chesbrough 2003). Specifically, the literature has emphasised the critical role of universities and research institutions as a source of knowledge (Laursen and Salter 2004; Fabrizio 2009; Grimpe and Sofka 2009; Cosh and Huges 2010; Sofka and Grimpe 2010; Berkers and Geels 2011; Chen et al. 2011). This interest in universities is mainly related to the increasing movement in literature that underlines the necessity of science in combining unknown components (Ulrich 1995; Baldwin and Clark 2000; Fleming and Sorenson 2001; Fleming and Sorenson 2004; Gruber et al. 2012). Indeed, academic knowledge fosters radical innovations (Paananen 2009) and long-term and sustainable competitive advantage (Makri and Lane 2007). Nevertheless, it remains unclear for which firms and for which industries the contribution of universities is more relevant. Grimpe and Sofka (2009) have proven that academic knowledge is preferred by high- and medium-technology industries. Berkers and Geel (2011) have verified the importance of universities in more low-tech sectors. In addition, more research is needed to examine which practices firms should employ to develop scientific-based recombinations. Another gap that needs to be filled involves how the relationships between universities and firms change according to whether the academic institutes are privately or publicly owned.

The literature has identified the methods firms use to establish relationships with external sources, especially with other firms, and then to acquire knowledge elements. Specifically, the recombinant search perspective has identified two meaningful solutions: mobility of employees (Almeida and Kogut 1999; Song et al. 2001; Rosenkopf and Almeida 2003) and alliances (Powell et al. 1996; Stuart and Podolny 1996; Rosenkopf and Almeida 2003; Padula 2008; Schoenmakers and Duysters 2010). Regarding the types of alliance, a specific need has emerged: blending sparseness and cohesiveness (Padula 2008). Nevertheless, scholars have provided few experimental managerial solutions to build and exploit alliance portfolios. One example is the networks of strategic communities Fujitsu Limited has adopted in Japan (Kodama 2005). A deeper investigation of how to design a portfolio of alliances that combines sparseness and cohesiveness is required. In particular, future research should specify the firm and industry typologies that could benefit from this solution. Evidence coming from the open innovation literature has suggested crowdsourcing as a method to acquire knowledge from external sources (Jeppesen and Lakhani 2010). Indeed, by soliciting contributions from an online community of users, it is possible to acquire knowledge from sources distributed across the world (Von Hippel 2001; Benkler 2006). Hence, the identification of new methods to access external knowledge may achieve more useful results with the integration of recombinant search and open innovation theories. Finally, an analysis

of how firms can relate to universities is lacking. In particular, it is not clear whether alliances and inventor mobility are useful when firms and universities decide to collaborate.

In addition, our findings revealed that geographical area is a fundamental dimension to define the strategy of external knowledge search (Ahuja and Katila 2004; Kriauciunas and Kale 2006; Phene et al. 2006; Li and Vanhaverbeke 2009). Specifically, crossing geographical boundaries helps to search for novel solutions, especially for big and multinational firms operating in the chemical and biotechnology industries (Ahuja and Katila 2004; Kriauciunas and Kale 2006; Phene et al. 2006). In this regard, scholars have underlined that a geographically distant element cannot also be technologically distant (Phene et al. 2006). In addition, a stream of research has posed the issue of cultural distance combined with geographical distance (Kriauciunas and Kale 2006; Li and Vanhaverbeke 2009). Indeed, knowledge sharing among partners in distant places may be facilitated by similar language, institutions, and culture (Li and Vanhaverbeke 2009). However, studies on how small and medium-sized firms within low-tech industries may search for and recombine geographically and culturally distant elements are lacking. Since we are in the explorative phase of research in this topic, we suggest it would be useful to adopt a single case study or a multiple case study methodology to comprehend the phenomenon.

Regarding ties with external sources, the recombinant literature presents a debate not yet solved on the efficient number of sources from which to source new knowledge. In particular, some scholars have found a strong relationship between drawing deeply from a small number of sources and radical innovation (Laursen and Salter 2006), while others have observed the opposite effect (Chiang and Hung 2010). Nevertheless, recent studies have highlighted the importance of considering the types of external sources (Chen et al. 2011), opening the door to further analysis. Accordingly, future studies could be focused on better understanding the effects of openness by simultaneously analysing the impact exerted by country, industry, and market characteristics on the scope and depth of external search strategies, as well as how these impacts depend on the organisation's internal innovative capacity.

From a methodological point of view, the empirical research we selected for this innovation management literature review of recombinant search frequently relies on the analysis of archival data coming from patents. However, this is not the only kind of research methodology we encountered. Some papers regarding inventors used the multiple case study method. Articles about firms, however, both within and beyond organisational boundaries, are generally based on surveys. Nevertheless, many of the research gaps we identified in this research work may be filled by using the inductive approach of the single case study. Indeed,

the case study methodology may be efficient to explore specific theoretical issues about recombinant search which lack adequate empirical evidence, such as new methods of socialisation, the relationships between public or private universities and firms, and the recombinant process of external knowledge for small and medium-sized firms.

The established framework and the summary of the empirical evidence presented in this review (see Table 3) offer a detailed comprehension of the recombinant view of innovation. Furthermore, this study offers suggestions for future research and provides a novel point of view by underlining the differences and strengths of both inventors and firms in search and recombination.

< Insert Table 3 about here >

References

Abecassis-Moedas, C. and Mahmoud-Jouni, S.B. (2008). Absorptive capacity and source recipient complementarity in designing new products: an empirical derived framework. *Journal of Product Innovation Management*, **25**, pp. 473-490.

Adams, R., Bessant, J. and Phelps, R. (2006). Innovation management measurement: A review. *International Journal of Management Reviews*, **8**, pp. 21-47

Ahuja, G. and Katila, R. (2004). Where do resources come from? The role of idiosyncratic situations. *Strategic Management Journal*, **25**, pp. 887–907.

Ahuja, G. and Lampert, C.M. (2001). Entrepreneurship in the large corporation: a longitudinal study of how established firms create breakthrough inventions. *Strategic Management Journal*, **22**, pp. 521-543.

Ahuja, G., Lampert, C.M. and Tandon, V. (2008). Moving beyond Schumpeter: Management Research on the determinants of technological innovation. *Academy of Management Annals*, **2**, pp. 1-98

Allen, T.J. (1977). *Managing the flow of technology: technology transfer and the dissemination of technological information within the R&D organization.* MIT Press, MA: Cambridge.

Almeida, P. and Kogut, B. (1999). The localization of knowledge and mobility of engineers in regional networks. *Management Science*, **45**, pp. 905–917.

Amabile, T.M. (1983). *The Social Psychology of Creativity*. Springer Verlag, NY: New York.

Amin, A., and Cohendet, P. (2004). *Architectures of knowledge.* Oxford University Press, NY: New York

Amit, R. and Zott, C. (2001). Value creation in e-business. *Strategic Management Journal*, **22**, pp. 493–520

Anderson, J. and Bower, G.H. (1973). *Human Associative Memory*. Halstead, NY: New York.

Argyres, N.S., and Silverman, B.S. (2004). R&D, organization structure, and the development of corporate technological knowledge. *Strategic Management Journal*, **25**, pp. 929-958

Armstrong, S. and Wilkinson, A. (2007). Processes, procedures and journal development: past, present and future. *International Journal of Management Reviews*, **9,** pp. 81–93.

Arthur, B. (2007). The structure of invention. *Research Policy*, **36**, pp. 274-287

Audia, P.G., and Goncalo, J.A. (2007). Success and creativity over time: A study of inventors in the hard-disk drive industry. *Management Science*, **53**, pp. 1-15

Baldwin, C.Y. and Clark, K.B. (2000). *Design Rules: The Power of Modularity*. MIT Press, MA: Cambridge.

Banbury, C. and Mitchell, V.V. (2007.) The effect of introducing important incremental innovations on market share and business survival. *Strategic Management Journal*, **10**, pp. 161-182.

Batenburg, R. and Rutten, R. (2003). Managing innovation in regional supply networks: a Dutch case of "knowledge industry clustering". *Supply Chain Management: An International Journal*, **8**, pp. 263-270.

Beamish, P.W., and Lupton, N.C. (2009). Managing joint ventures. *The Academy of Management Perspectives*, **23**, pp. 75-94

Beckert, J. (2003). Economic sociology and embeddedness: How shall we conceptualize economic action? *Journal of Economic Issues*, **3**, pp. 769-787

Belenzon, S. (2012). Cumulative innovation and market value: Evidence from patent citations. *The Economic Journal*, **122**, pp. 265-285

Belussi, F., Sammarra, A. and Sedita, S.R. (2010). Learning at boundaries in an "open regional innovation system": a focus on firms' innovation strategies in the Emilia-Romagna life science industry. *Research Policy*, **39**, pp. 710-721.

Benkler, Y. (2006). *The wealth of networks: How social production transforms markets and freedom*. Yale University Press, CT: New Haven

Bercovitz, J. and Feldman, M. (2011). The mechanisms of collaboration in inventive teams: Composition, social networks, and geography. *Research Policy*, **40**, pp. 81-93

Berkers, E. and Geels, F.W. (2011). System innovation through stepwise reconfiguration: the case of technological transitions in Duthc greenhouse horticulture (1930-1980). *Technology Analysis & Strategic Management*, **28**, pp. 227-247

Bogers, M., and West, J. (2012). Managing distributed innovation: Strategic utilization of open and user innovation. *Creativity and Innovation Management*, **21**, pp. 61-75

Bonesso, S., Comacchio, A. and Pizzi, C. (2011). Technology sourcing decisions in exploratory projects. *Technovation,* **31**, pp. 573-585.

Borgatti, S.P., and Cross, R. (2003). A relational view of information seeking and learning in social networks. *Management Science,* **49**, pp. 432-445

Boxenbaum, E. and Battilana, J. (2005). Importation as innovation: transposing managerial practices across fields. *Strategic Organization*, **3**, pp. 355-383

Breslin, D. (2011). Reviewing a generalized darwinist approach to studying socio-economic change. *International Journal of Management Reviews*, **13**, pp. 218-235

Burt, R.S. (2005). *Brokerage and closure.* Oxford University Press, NY: New York

Cantù, C. (2010). Exploring the role of spatial relationships to transform knowledge in a business idea – beyond a geographic proximity. *Industrial Marketing Management*, **39**, pp. 887–897.

Capaldo, A. and Messeni Petruzzelli, A. (2011). In search of alliance-level relational capabilities: balancing innovation value creation and appropriability in R&D alliances. *Scandinavian Journal of Management,* **27**, pp. 273-286

Carmeli, A. and Azeroual, B. (2009). How relational capital and knowledge combination capability enhance the performance of work units in a high technology industry. *Strategic Entrepreneurship Journal*, **3**, pp. 85-103

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

Chaney, H. and Devinney, T. (1992). New product innovations and stock price performance. *Journal of Business Finance and Accounting*, **19**, pp. 677-695.

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

Chesbrough, H.W. (2003). The era of open innovation. *Sloan Management Review,* **44**, pp. 35-41

Chiang, Y.H. and Hung, K.P. (2010). Exploring open search strategies and perceived innovation performance from the perspective of inter-organizational knowledge flows. *R&D Management*, **40**, pp. 292-299

Christoffersen, J. (2013). A review of antecedents of international strategic alliance performance: Synthesized evidence and new directions for core constructs. *International Journal of Management Reviews*, **15**, pp.66-85.

Cillo, P. and Verona, G. (2008). Search styles in style searching: exploring innovation strategies in fashion firms. *Long Range Planning*, **41**, pp. 650-671.

Cohen, W. and Levinthal, D. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, **35**, pp. 128-152.

Collins, A.M. and Quillian, M.R. (1969). Retrieval time from semantic memory. *Journal of Verbal Learning and Verbal Behavior*, **8**, pp. 240-247.

Coombs, J.E., Deeds, D.L. and Ireland, R.D. (2009). Placing the choice between exploration and exploitation in context: a study of geography and new product development. *Strategic Entrepreneurship Journal*, **3**, pp. 261-279.

Corso, M., Martini, A., Paolucci, E. and Pellegrini, L. (2011). Knowledge management in product innovation: An interpretative review. *International Journal of Management Reviews*, **3**, pp. 341-352

Cosh, A. and Hughes, A. (2010). Never mind the quality feel the width: University-industry links and government financial support for innovation in small high-technology businesses in the UK and the USA. *The Journal of Technology Transfer*, **35**, pp. 66-91

Csikszentmihalnyi, M. (2009). *Creativity: Flow and the psychology of discovery.* Harper Collins

Cusumano, M.A., and Nobeoka, K. (1992). Strategy, structure and performance in product development: Observations from the auto industry. *Research Policy*, **21**, pp. 265-293

Dacin, M.T., Ventresca, M.J. and Beal, B.D. (1999). The embeddedness of organizations: Dialogue & Directions. *Journal of Management*, **25**, pp. 317-356

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

Darden, L. (1980). Theory construction in genetics. In Nickles, T. (Ed.), *Scientific discovery:case studies*. Boston: D. Reidel Publishing Company, pp. 151-170

Darr, E.R. and Kurtzberg, T.R. (2000). An investigation of partner similarity dimensions on knowledge transfer. *Organization Behavior and Human Decision Processes*, **82**, pp. 28-44

Davenport, S. (2005). Exploring the role of proximity in SME knowledge-acquisition. *Research Policy*, **34**, pp. 683-701

David, P.A. (1998). Knowledge spillovers, technology transfers, and the economic rationale for public support of exploratory research in science. *Background paper for European Committee for future Accelerators*

Davis, J.P. and Eisenhardt, K.M. (2011). Rotating leadership and collaborative innovation: Recombination processes in symbiotic relationships. *Administrative Science Quarterly*, **56**, pp. 159-201

De Boer, M., Van den Bosch, F.A.J. and Volberda, H.W. (1999). Managing organizational knowledge integration in the emerging multimedia complex. *Journal of Management Studies*, **36**, pp. 379-398

Dodgson, M. (2011). Exploring new combinations in innovation and entrepreneurship: social networks, Schumpeter, and the case of Josiah Wedgwood (1730-1795). *Industrial and Corporate Change*, **20**, pp. 1119-1151.

Dosi, G. (1978). Technological paradigms and technological trajectories. A suggested interpretation of the determinants and directions of technical change. *Research Policy*, **11**, pp. 147-162

DTI. (2003). *U.K. Innovation Survey.* Department of Trade and Industry, UK: London

Ellis, H.C. (1965). *The transfer of learning.* Macmillan, UK: Oxford

Ericsson, K.A., and Lehmann, A.C. (1996). Expert and exceptional performance: Evidence of maximal adptation to task constraints. *Annual Review of psychology*, **47**, pp. 273-305

Ettlie, J.E. and Kubarek, M. (2008). Design Reuse in manufacturing and services. *Journal of Product Innovation Management*, **25**, pp. 457-472

EUROSTAT. (2011). European Economic Statistics 2010 Edition. *European Union: Belgium.*

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

Feist, G.J., and Gorman, M.E. (1998). The psychology of science: review and integration of a nascent discipline. *Review of General Psychology*, **2**, pp. 3-47

Fixson, S.K. and Lee, W.H. (2012). Shifting grounds: how industry emergence changes the effectiveness of knowledge creation strategies – the case of the US automotive airbag industry. *Technology Analysis & Strategic Management*, **24**, pp. 1-19

Fleming, L. (2001). Recombinant uncertainty in technological search. *Management Science*, **47**, pp. 117-132.

Fleming, L. (2002). Finding the organizational sources of technological breakthroughs: the story of Hewlett-Packard's thermal ink-jet. *Industrial and Corporate Change*, **11**, pp. 1059-1084

Fleming, L. and Sorenson, O. (2001). Technology as a complex adaptive system: evidence from patent data. *Research Policy*, **30**, pp. 1019-1039

Fleming, L. and Sorenson, O. (2004). Science as a map in technological search. *Strategic Management Journal*, **25**, pp. 909-928.

Fosfuri, A. and Tribò, J.A. (2008). Exploring the antecedents of potential absorptive capacity and its impact on innovation performance. *Omega. The International Journal of Management Science*, **36**, pp. 173-187.

Freddi, D. (2009). The integration of old and new technological paradigms in low- and medium-tech sectors: The case of mechatronics. *Research Policy*, **38**, pp. 548–558

Frenken, K., Izquierdo, L.R. and Zeppini, P. (2012). Branching innovation, recombinant innovation and endogenous technological transitions. *Environmental Innovation and Societal Transitions*, **4**, pp. 25-35

Galunic, C.D. and Rodan, S. (1998). Resource recombinations in the firm: Knowledge structures and the potential for Schumpeterian innovation. *Strategic Management Journal*, **19**, pp.1193-1209.

Galunic, D.C. and Eisenhardt, K.M.. (2001). Architectural innovation and modular corporate forms *Academy of Management Journal*, **44**, pp. 1229-1249

Garud, R., Gehman, J. and Kumaraswamy, A. (2011). Complexity arrangements for sustained innovation: lessons from 3M Corporation. *Organization Studies*, **32**, pp. 737-767

Gavetti, G. and Levinthal, D. (2000). Looking forward and looking backward: Cognitive and experiential search *Administrative Science Quarterly*, **45,** pp. 113-137

Gentner, D. (1982). Are scientific analogies metaphors? In Miall, D.S. (Ed.), *Metaphor: Problems and perspectives*. Brighton: Harvester, pp. 106-132

Gerybadze, A. and Reger, G. (1999). Globalization of R&D: recent changes in the management of innovation in transnational corporations. *Research Policy*, **28**, pp. 251-274

Gilfillan, S.C. (1935). *Inventing the ship: a study of the inventions made in her history between floating log and rotorship*. Follet, IL: Chicago.

Gilsing, V., Nooteboom, B., Vanhaverbeke, W., Duysters, G. and Van den Oord, A. (2008). Network embeddedness and the exploration of novel technologies: technological distance, betweenness centrality and density. *Research Policy*, **37**, pp. 1717-1731.

Gold, A.H., Malhotra, A., and Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems*, **18**, pp. 185-214

Gopalakrishnan, S. and Damanpour, F. (1997). A review of innovation research in economics, sociology and technology management. *Omega, The International Journal of Management Science*, **25**, pp. 15–28.

Grant, R.M. (1991). The Resource-based theory of competitive advantage: Implications for strategy formulation. *California Management Review*, **33**, pp. 114-135

Grant, R.M. (1996). Competitive environments. Organizational capability as knowledge integration. *Organization Science*, **4**, pp. 375-387

Green, S.G., Gavin, M.B. and Aiman-Smith, L. (1995). Assessing a multidimensional measure of radical technological innovation. *IEEE Transactions on Engineering Management,* **42**, pp. 203-214

Greis, N.P., Dibner, M.D. and Bean, A.S. (1995). External partnering as response to innovation barriers and global competition in biotechnology. *Research Policy,* **24**, pp. 609-630.

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

Gronlund, J., Sjodin, D.R. and Frishammar, J. (2010). Open innovation and the stage-gate process: A revised model for new product development. *California Management Review,* **52**, pp. 106-131

Gruber, M., Harhoff, D. and Hoisl, K. (2012). Open innovation and the stage-gate process: A revised model for new product development. *Management Science,* **forthcoming**

Gulati, R., and Puranam, P. (2009). Renewal through reorganization: the value of inconsistencies between formal and informal organization. *Organization Science,* **20**, pp. 422-440

Gupta, A.K., Tesluk, P.E. and Taylor, M.S. (2007). Innovation at and across multiple levels of analysis. *Organization Science,* **18**, pp. 885-897

Haefliger, S., Von Krogh, G. and Spaeth, S. (2008). Code reuse in open source software. *Management Science*, **54**, pp. 180-193.

Hargadon, A. and Sutton, R. (1997). Technology brokering and innovation in a product development firm. *Administrative Science Quarterly,* **42**, pp. 716-749

Hargadon, A.B. (2002). Brokering knowledge: linking learning and innovation. *Research in Organizational Behavior,* **24**, pp. 41-85.

Harryson, S.J. (1997). How Canon and Sony drive product innovation through networking and application-focused R&D. *Journal of Product Innovation Management,* **14**, pp. 288-295

Harryson, S.J., Hitt, M.A., Hoskisson, R.E. and Ireland, D.R. (1991). Synergies and Post-acquisition performance: Differences versus similarities in resource allocations. *Journal of Management,* **17**, pp. 173-190

Harryson, S.J., Hitt, M.A., Hoskisson, R.E. and Ireland, D.R. (2001). Resources Complementarity in Business combinations: Extending the logic to organization alliances. *Journal of Management,* **27**, pp. 679-690

Helfat, C.E. and Eisenhardt, K.M. (2004). Inter-temporal economies of scope, organizational modularity, and the dynamics of diversification. *Strategic Management Journal,* **25**, pp. 1217-1232

Henderson, R.M. and Clark, K.B. (1990). Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly*, **35**, pp. 9-30

Herrmann, A.M. and Peine, A. (2011). When 'national innovation system' meet 'varieties of capitalism' arguments on labour qualifications: On the skill types and scientific knowledge needed for radical and incremental product innovations. *Research Policy,* **40**, pp. 687-701

Hirsch, P.M. (1972). Processing fads and fashions: an organization-set analysis of cultural industry systems. *American Journal of Sociology*, **77**, pp. 639-659.

Hirsch, P.M. (2000). Cultural industries revisited. *Organization Science,* **11**, pp. 356-361.

Huggins, R. (2010). Forms of network resource: Knowledge access and the role of inter-firm networks. *International Journal of Management Reviews,* **12**, pp. 335-352

Hurley, R.F. and Hult, G.T. (1998). Innovation, market orientation, and organizational learning: An integration and empirical examination. *Journal of Marketing*, **62**, pp. 42–54.

IIT Research Institute. (1968). *Technology in retrospect and critical events in science*. National Science foundation, D.C.: Washington

Inkpen, A.C., and Tsang, E.W.K. (2002). Social capital, networks, and knowledge transfer. *Academy of Management Review*, **30**, pp. 146-165

Jacobson, A. and Prusak, L. (2006). The cost of knowledge. *Harvard Business Review*, **84**, pp. 34

Jansen, J.J.P., Van den Bosch, F.A.J. and Volberda, H.W. (2006). Exploratory innovation, exploitative innovation, and financial performance: how do organizational antecedents and environmental moderators matter?. *Management Science*, **52**, pp. 1661-1674

Jeppensen, L.B., and Lakhani, K.R. (2010). Marginality and problem-solving effectiveness in broadcast search. *Organization Science*, **21**, pp. 1016-1033

Kalogerakis, K., Luthje, C. and Herstatt, C. (2010). Developing innovation based on analogies: experience from design and emerging consultants. *Journal of Product Innovation Management*, **27**, pp. 418-436.

Karim, S., (2006). Modularity in organizational structure: the reconfiguration of internally developed and acquired business units. *Strategic Management Journal*, **27**, pp. 799–823

Karim, S., (2009). Business unit reorganization and innovation in new product markets. *Management Science*, **55**, pp. 1237-1254.

Katila, R. (2002). New product search over time: past ideas in their prime? *Academy of Management Journal*, **45**, pp. 995-1010

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

Katila, R. and Chen, E.L. (2008). Effects of search timing on innovation: the value of not being in sync with rivals. *Administrative Science Quarterly*, **53**, pp. 593-625

Keane, M.T. (1988). *Analogical problem solving.* Ellis Horwood, UK: Chichester

Kieser, A. and Koch, U. (2008). Bounded rationality and organizational learning based on rule changes. *Management Learning*, **39**, pp. 329-347.

Klahr, D., and Simon, H.A. (1999). Studies of scientific discovery: Complementary approaches and convergent findings. *Psychological Bulletin*, **125**, pp. 524-543

Klein, K.J., and Sorra, J.S. (1996). The challenge of innovation implementation. *Academy of Management Review*, **21**, pp. 1055-1080

Knight, J.C. and Dunn, M.F. (1998). Software quality through domain-driven certification. *Annals of Software Engineering*, **5**, pp. 293-315

Knudsen, M.P. (2007). The relative importance of interfirm relationships and knowledge transfer for new product development success. *Journal of Product Innovation Management*, **24**, pp. 117-138

Kodama, M. (1999). Strategic innovation at large companies through strategic community management: An NTT multimedia revolution case study. *European Journal of Innovation Management*, **2**, pp. 95-108

Kodama, M. (2005). Knowledge creation through networked strategic communities. Case studies on new product development in Japanese Companies. *Long Range Planning*, **38**, pp. 27-49

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

Kogut, B., and Zander, U. (1993). Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies,* **24**, pp. 625-645

Kotlarsky, J., Oshri, I., Van Hillegersberg, J. and Kumar, K. (2007). Globally distributed component-based software development: an exploratory study of knowledge management and work division. *Journal of Information Technology,* **22**, pp. 161-173

Kriauciunas, A. and Kale, P. (2006). The impact of socialist imprinting and search on resource change: a study of firms in Lithuania. *Strategic Management Journal*, **27**, pp. 659-679

Laursen, K. and Salter, A. (2004). Searching high and low: what types of firms use universities as a source of innovation? *Research Policy*, **33**, pp. 1201-1215.

Laursen, K. and Salter, A. (2006). Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal,* **27**, pp. 131-150

Lefebvre, L.A., Mason, R. and Lefebvre, E. (1997). The influence prism in SMEs: the power of CEOs' perceptions on technology policy and its organizational impacts. *Management Science,* **43**, pp. 856-878

Leiponen, A. and Helfat, C.E. (2009). Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal*, **31**, pp. 224-236

Lengnick-Hall, C.A. (1992). Innovation and competitive advantage: What we know and what we need to learn. *Journal of Management,* **18**, pp. 399-429

Lettl, C., Gemuenden, H.G. and Hestatt, C. (2006). Users' contributions to radical innovation: Evidence from four cases in the field of medical equipment technology. *R&D Management,* **36**, pp. 251-272.

Levinthal, D. and March, J. (1993). The myopia of learning. *Strategic Management Journal*, **14**, pp. 95-113

Li, Y. and Vanhaverbeke, W. (2009). The effects of inter-industry and country difference in supplier relationships on pioneering innovations. *Technovation,* **29**, pp. 843-858

Lichtenthaler, U. (2011). Open innovation: Past research, current debates, and future directions. *The Academy of Management Perspectives*, **25**, pp. 75-93

Maggitti, P.G., Smith, K.G. and Katila, R. (2013). The complex search process of invention. *Research Policy*, **42**, pp. 90-100.

Majchrzak, A., Cooper, L.P. and Neece, O.N. (2004). Knowledge reuse for innovation. *Management Science*, **50**, pp. 174-188.

Makri, M. and Lane, P.J. (2007). A search theoretic model of productivity, science and innovation. *R&D Management,* **37**, pp. 303-317

Makri, M., Hitt, M.A. and Lane, P.J. (2010). Complementary technologies, knowledge relatedness, and invention outcomes in high technology mergers and acquisitions. *Strategic Management Journal*, **31**, pp. 602-628.

March, J. (1991). Exploration and exploitation in organizational learning. *Organization Science*, **2**, pp. 71-87.

March, J.G. and Simon, H.A. (1958). *Organizations.* Wiley, UK: Oxford

Meier, M. (2011). Knowledge Management in Strategic Alliances: A review of Empirical Evidence.
International Journal of Management Reviews, **13**, pp. 1-23.

Messeni Petruzzelli, A. and Albino, V. (2012). *When tradition turns into innovation. How firms can create and appropriate value through tradition*. Woodhead Publishing Limited, UK: Cambridge

Messeni Petruzzelli, A. and Savino, T. (2012). Search, recombination, and innovation: lessons from haute cuisine. *Long Range Planning*, forthcoming.

Messeni Petruzzelli, A., Rotolo, D. and Albino, V. (2012). The impact of old technologies on innovation: the case of the US biotechnology industry. *Technology Analysis & Strategic Management*, **24**, pp. 453-466.

Miller, D.J., Fern, M.J. and Cardinal, L.B.. (2007). The use of knowledge for technological innovation within diversified firms. *Academy of Management Journal*, **50**, pp. 308-326.

Monteiro, L.F., Arvidsson, N. and Birkinshaw, J. (2008). Knowledge flows within multinational corporations: explaining subsidiary isolation and its performance implications. *Organization Science*, **19**, pp. 90-107.

Moran, P. and Ghoshal, S. (1999). Markets, firms, and the process of economic development. *The Academy of Management Review*, **24**, pp. 390–412.

Mowery, D. and Rosenberg, N. (1979). The influence of market demand upon innovation: a critical review of some recent empirical studies. *Research Policy*, **8**, pp. 102–153.

Mowery, D., Oxley, J. and Silverman, B. (1996). Strategic alliances and interfirm knowledge transfer. *Strategic Management Journal*, **17** (Winter Special Issue), pp. 77-92.

Mowery, D., Oxley, J. and Silverman, B. (1998). Technological overlap and interfirm cooperation: Implications for the resource-based view of the firm, *Research Policy*, **27**, pp. 507-523

Muethel, M., and Hoegl, M. (2010). Cultural and societal influences on shared leadership in globally dispersed teams. *Journal of International Management*, **16**, pp. 234-246

Mytelka, L.K. (1999). *Competition, innovation and competitiveness in developing countries*. OECD Publications, Paris.

Nelson, R. and Winter, S. (1982). *An Evolutionary Theory of Economic Change*. Harvard University Press, MA: Cambridge.

Nerkar, A. (2003). Old is gold? The value of temporal exploration in the creation of new knowledge. *Management Science* **49**, pp. 211-229

Ogburn, W.F. (1922). *Social Change*. B.W. Huebsch, NY: New York

Olsson, O., and Frey, B.S. (2012). Entrepreneurship as recombinant growth. *Small Business Economics*, **19**, pp. 69-80

Paananen, M. (2009). Exploring the relationships between knowledge sources in the innovation process: evidence from finnish innovators. *Technology Analysis & Strategic Management*, **21**, pp. 711-725

Paananen, M. (2012). I'll find it where I can: Exploring the role of resource and financial constraints in search behavior among innovators. *Industry and Innovation*, **16**, pp. 63-84

Padula, G. (2008). Enhancing the innovation performance of firms by balancing cohesiveness and bridging ties. *Long Range Planning*, **41**: 395-419.

Perkins, D.N. (1995). Insight in minds and genes. In Sternberg, R.J. and Davidson, J.E. (Eds.), *The nature of insight*. Cambridge: MIT Press, pp. 495-534

Perretti, F. and Negro, G. (2007). Mixing genres and matching people: a study in innovation and team composition in Hollywood. *Journal of Organizational Behavior*, **28**, pp. 563-586

Persaud, A. (2005). Enhancing synergistic innovative capability in multinational corporations: an empirical investigation. *Journal of Product Innovation Management*, **22**, pp. 412-429

Phene, A., Fladmoe-Lindquist, K. and Marsh, L. (2006). Breakthrough innovations in the U.S. Biotechnology industry: The effects of technological space and geographic origin. *Strategic Management Journal*, **27**, pp. 369-388.

Pittaway, L., Robertson, M., Munir, K., Denyer, D. and Neely, A. (2006). Networking and innovation: A systematic review of the evidence. *International Journal of Management Reviews*, **5**, pp. 137-168.

Pohl, H. and Elmquist, M. (2010). Radical innovation in a small firm: a hybrid electric vehicle development project at Volvo Cars. *R&D Management*, **40**, pp. 372-382

Polanyi, K. (1944). *The great transformation: the political and economic origins of our time.* Beacon Press, MA: Boston

Polanyi, M. (1966). *The tacit dimension.* Routledge and Kegan Paul, UK: London

Porter, M.E. (2000). Location, competition, and economic development: Local clusters in a global economy. *Economic Development Quarterly*, **14**, pp. 15–34.

Potts, J. (2000). *The new evolutionary microeconomics*. Edward Elgar, UK: Cheltenham

Powell, W., Koput, K. and Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, **41**, pp. 116-145

Reagans, R. and McEvil, B. (2003). Network Structure and Knowledge Transfer: The Effects of Cohesion and Range, *Administrative Science quarterly*, **48**, pp. 240-267

Reed, R., and De Filippi, R.J. (1990). Causal ambiguity, barriers to imitation and sustainable competitive advantage. *Academy of Management Review*, **15**, pp. 88-102

Reeves, L.M., and Weisberg, R.W. (1993). On the concrete nature of human thinking: content and context in analogical transfer. *Educational Psychology*, **13**, pp. 245-258

Rhodes, M. (1961). An analysis of creativity. *Phi Delta Kappan*, **42**, pp. 305-310

Ribot, T. (1906). *Essays on the creative Imagination*. Routledge & Kegan Paul, UK: London.

Rigby, D. and Zook, C. (2002). Open-market innovation. *Harvard Business Review*, **80**, pp. 80-89

Rogers, E.M. (1995). *Diffusion of innovations*. The Free Press, NY: New York

Rosenkopf L. and Nerkar A. (2001). Beyond local search: boundary-spanning, exploration, and impact in the optical disc industry. *Strategic Management Journal*, **22**, pp. 287-306.

Rosenkopf, L. and Almeida, P. (2003). Overcoming local search through alliances and mobility. *Management Science*, **49**, pp. 751-766.

Rothwell, R., Freeman, C., Horsley, A., Jervis, V.T.P., Robertson, A.B. and Townsend, J. (1974). SAPPHO Updated-Project Sappho Phase II. *Research Policy*, **3**, pp. 258-291

Salvato, C. (2003). The role of micro-strategies in the engineering of firm evolution. *Journal of Management Studies*, **40**, pp. 83-108.

Sammarra, A. and Biggiero, L. (2008). Heterogeneity and specificity of inter-firm knowledge flows in innovation networks. *Journal of Management Studies*, **22**, pp. 287-306.

Sanchez, R., and Mahoney, J.T. (1996). Modularity, flexibility, and knowledge management in product and organizational design. *Strategic Management Journal*, **17**, pp. 63-76

Sapienza, H.J., Parhankangas, A., and Autio, E. (2004). Knowledge relatedness and post spin-off growth. *Journal of Business Venturing*, **19**, pp. 809-829

Schilling, M.A. and Green, E. (2011). Recombinant search and Breakthrough idea generation: an analysis of high impact papers in the social science. *Research Policy*, **40**, pp. 1321-1331

Schilling, M.A. and Phelps, C. (2007). Interfirm collaboration networks and knowledge creation: the impact of large scale network structure on firm innovation. *Management Science*, **53**, pp. 1113–1126.

Schoenmakers, W. and Duysters, G. (2010). The technological origins of radical inventions. *Research Policy*, **39**, pp. 1051-1059

Schon, D.A. (1993). Generative metaphor: A perspective on problem-setting in social policy. In Ortony, A. (eds), *Metaphor and Thought*. Cambridge: Cambridge University Press.

Schoonhoven, C., Eisenhardt, K. and Lyman, K. (1990). Speeding products to market: waiting time to first product introduction in new firms. *Administrative Science Quarterly*, **35**, pp. 177-207

Schulze, A. and Hoegl, M. (2008). Organizational knowledge creation and the generation of new product ideas: a behavioral approach. *Research Policy*, **3**, pp. 1742-1750

Schumpeter, J. (1939). *Business Cycles*. McGraw-Hill, NY: New York.

Sheremata, W.A. (2002). Finding and solving problems in software new product development. *Journal of Product Innovation Management*, **19**, pp. 144-158

Silverberg, G., and Verspagen, B. (2005). A percolation model of innovation in complex technology spaces. *Journal of Economic Dynamics & Control*, **29**, pp. 225-244

Simmie, J. (2003). Innovation and urban regions as national and international nodes for the transfer and sharing of knowledge. *Regional Studies*, **37**, pp. 607–620.

Simon, H.A. (1973). The structure of ill-structured problems. *Artificial Intelligence*, **4**, pp. 181-201

Simon, H.A. (1977). *Models of discovery.* Reidel, Holland: Dordrecht

Simon, H.A. (1978). Rationality as process and product of thought. *American Economic Review: Proceedings*, **68**, pp. 1-16

Simon, H.A. (1991). Bounded rationality and organizational learning. *Organization Science,* **2**, pp. 125-134

Singh, J. (2008). Distributed R&D, cross-regional knowledge integration and quality of innovative output. *Research Policy*, **37**, pp. 77-96

Singh, J. and Fleming, L. (2010). Lone inventors as source of breakthrough: Myth or reality? *Management Science*, **56**, pp. 41-56

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

Song, J., Almeida, P. and Wu, G. (2001). Mobility of engineers and cross-border knowledge building: The technological catching-up case of Korean and Taiwanese semiconductor firms. In Chesbrough, H. and Burgelman, R. (eds) *Research in Technology and Innovation Management*. New York: JAI Press.

Sørensen, J.B. and Stuart, T.E. (2000). Aging, obsolescence, and organizational innovation. *Administrative Science Quarterly*, **45**, pp. 81–112

Sorenson, O., Rivkin, J.W. and Fleming, L. (2006). Complexity, networks, and knowledge flow. *Research Policy*, **35**, pp. 994-1017.

Sternberg, R.J. (2000). *Handbook of Intelligence*. Cambridge University Press, MA: Cambridge.

Storck, J. and Patricia, A.H. (2000). Knowledge diffusion through Strategic communities. *Sloan Management Review*, **41,** pp. 63-74

Stuart, T. and Podolny, J. (1996). Local search and the evolution of technological capabilities. *Strategic Management Journal*, **17** *(Summer Special Issue)*, pp. 21-38.

Taylor, A. and Greve, H. (2006). Superman or the fantastic four? Knowledge combination and experience in innovative teams. *Academy of Management Journal*, **49**, pp. 723-740

Teece, D. and Pisano, G. (1994). The dynamic capabilities of firms: an introduction. *Industrial and Corporate Change*, **3**, pp. 537-556

Teece, D., Pisano, G., and Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, **18**, pp. 509-533

Teece, D.J. (1996). Firm organization, industrial structure, and technological innovation. *Journal of Economic Behavior & Organization*, **31**, pp. 193-224

Terziovski, M. (2010). Innovation practice and its performance implications in small and medium enterprises (SMEs) in the manufacturing sector: a resource based view. *Strategic Management Journal*, **31**, pp. 892-902

Tidd, J. (2001). Innovation management in context: environment, organization and performance. *International Journal of Management Reviews*, **3**, pp. 169-183

Tolstoy, D. (2009). Knowledge combination and knowledge creation in a foreign market network. *Journal of Small Business Management*, **47**, pp. 202-220

Tran, Y. (2010). Generating stylistic innovation: a process perspective. *Industry and Innovation*, **17**, pp. 131-161

Tranfield, D., Denver, D. and Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, **14**, pp. 207-222.

Tripsas, M., (1997). Surviving radical technological change through dynamic capability: evidence from typesetter industry. *Industrial and Corporate Change*, **6**, pp. 341-377

Tzabbar, D., Aharonson, B.S., Amburgey, T.L. and Al-Laham, A. (2008). When is the whole bigger than the sum of its parts? Bunding knowledge stoks for innovative success. *Strategic Organization*, **6**, pp. 375-406

Ulrich, D., Kerr, S., and Ashkenas, R. (2002). *The GE Work-Out.* McGraw-Hill, NY: New York

Ulrich, K. (1995). The role of product architecture in the manufacturing firm. *Research Policy*, **24**, pp. 419–440.

Usher, A.P. (1929). *A History of Mechanical Inventions.* McGraw-Hill, NY: New York

van den Bergh, J.C.J.M. (2008). Optimal diversity: Increasing returns versus recombinant innovation. *Journal of Economic Behavior and Organization*, **68**, pp. 565-580

Veugelers, R. and Cassiman, B. (1999). Make and buy in innovation strategies: evidence from Belgian manufacturing firms. *Research Policy*, **28**, pp. 63-80

Vincenti, W. (1990). *What Engineers Know, and How They Know It*. Johns Hopkins University Press, MD: Baltimore.

von Hippel, E. (1988). *The sources of innovation.* Oxford University Press, UK: Oxford

von Hippel, E. (2001). Innovation by user communitites: learning from open-source software. *Sloan Management Review*, **42**, pp. 82-86

von Hippel, E. (2005). *Democratizing innovation*. The MIT Press, MA: Cambridge

Wang, H. and Li, J. (2008). Untangling the effects of overexploration and overexploitation on organizational performance: the moderating role of environment dynamism? *Journal of Management*, **34**, pp. 925-951.

Weisberg, R.W. (1999). Creativity and knowledge: A challenge to theories. In Sternberg, R.J. (Ed.), *Handbook of Creativity*. Cambridge: Cambridge University Press, pp. 226-250

Weitzman, M.L. (1998). Recombinant growth. *Quarterly Journal of Economics*, **113**, pp. 331-360

Wu, C. (2008). Knowledge creation in a supply chain. *Supply Chain Management: An International Journal*, **13**, pp. 241-250

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

Zahra, S.A., and Nielsen, A.P. (2002). Sources of capabilities, integration and technology commercialization. *Strategic Management Journal*, **23**, pp. 377-398

Zahra, S.A., Sapienza, H.J. and Davidsson, P. (2006). Entrepreneurship and dynamic capabilities: A review, model and research agenda. *Journal of Management Studies*, **43**, pp. 917-955.

Zander, I. (1997). Technological diversification in the multinational corporation-historical evolution and future prospects. *Research Policy*, **26**, pp. 209-227

Zander, I. (2007). Do you see what I mean? An entrepreneurship perspective on the nature and boundaries of the firm. *Journal of Management Studies*, **44**, pp. 1141-1164

Zander, U. and Kogut, B. (1995). Knowledge and speed of the transfer and imitation of organizational capabilities: an empirical test. *Organization Science*, **6**, pp. 76-92

Zhang, Y. and Li, H. (2010). Innovation search of new ventures in a technology transfer: the role of ties with service intermediaries. *Strategic Management Journal*, **31**, pp. 88-109

Ziman, J. (2000). Selectionism and complexity. In Ziman, J. (Ed.), *Technological Innovation as an Evolutionary Process*. Cambridge: Cambridge University Press, pp. 41-51

Table 1. Exclusion Criteria

No.	Criteria	Reason for exclusion
1	Pre-1992	The paper of Kogut and Zander (1992) is chosen as the point of reference for this review
2	Publication Type	Exclude books, book chapter, conference proceedings, dissertation abstracts, editorials, working papers, interviews, and research notes
3	Perspective	Exclude articles with algorithm, software, implementation of managing systems, plant management, and new model analysis validation

Table 2. Inclusion Criteria

No.	Criteria	Reason for inclusion
1	Quantitative and qualitative empirical studies	Extant empirical evidence represents the particular interest of this review
2	Innovation Management Outcomes	Examine how innovation processes are managed by searching and recombining knowledge, and how these influence performance
3	All industries	Provide a cross-industry overview
4	All countries	Provide a cross-country overview

Table 3. Summary of Research Findings

Level of Analysis	Findings	Research Gaps
Inventors	The access to knowledge elements coming from unrelated domains is necessary to develop breakthrough combinations.	Lack of an integrative approach to study inventive process of individuals by integrating the innovation management literature on the recombinant view with other streams (creativity, psychology).
	The main approach used to combine distant knowledge elements is analogy.	Lack of research on lone inventors' characteristics.
	The most effective mean to access to larger sets of knowledge is team involvement.	When referring to team involvement, it remains unclear the number of members, the breadth of competences, and experiences that more likely generate successful innovative outputs.
		Lacks of results on industry contextualization.
Within Firms Organizational Boundaries	Building social capital is one of the most effective mechanism to share knowledge among employees by reducing obstacles.	Lack of analysis about more attractive methods of socializations (to go beyond the usual joint coffee, lunch breaks, and periodical informal meetings).
	At a more formal and structured level, the means to share and recombine knowledge among members are mainly represented by corporate reconfigurations.	Lack of solutions that allow to reconfigure more easily and more effectively the firms' internal resources.
		Lack of analysis on corporate reconfigurations practices adopted in the major emerging national economies, as Brazil, Russia, India, China and South Africa.
		Lack of studies on the definition of organizational configurations most suited to specific technological and market environments.
		Lack of research on how multinational firms can integrate and exploit their variety of international and local employees.
	The reuse of prior knowledge is an increasing practice.	Lack of research on qualifying contingent conditions that enhance or reduce the contribution of aged knowledge in the

		innovation development. Lack of research on the value of aged components in low and medium technology industries and for small and medium firms.
Beyond Firms Organizational Boundaries	Universities provide useful knowledge to combine unknown components.	Lack of research on how implementing recombination by using external scientific knowledge.
	The recombination of scientific knowledge elements is related to the development of radical and enduring innovations.	Lack of research about the relationships between universities and firms, according to the ownership of academic institutes (private or public).
	Organizations can search and recombine knowledge of external partners by relying upon mobility of inventors or alliances.	Lack of quantitative empirical researches to identify which types of firm and industry benefit from alliances portfolio that combines sparseness and cohesiveness. Lack of analysis on how firms can relate with universities. It is not clear if alliances and mobility of inventors are useful when firms and universities decide to collaborate.
	Crossing geographical boundaries increases the sources and variety of acquired knowledge elements.	Lack of research on how firms in low tech industries can search and recombine culturally and geographically distant elements
	Trust is a fundamental driver to exchange knowledge among partners.	It is not solved the debate about the effects of depth and breadth of external search on innovative outcomes. Lack of research on external process for small and medium firms.

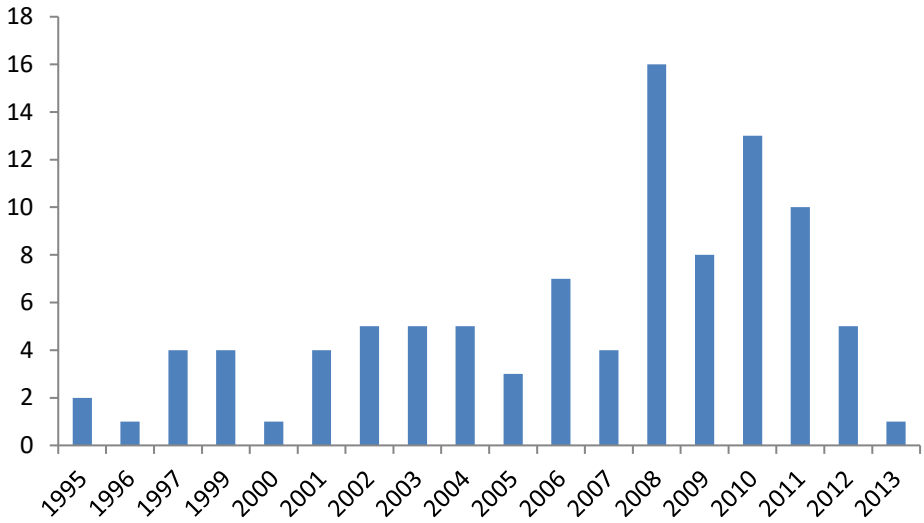

Figure 1. Number of articles per year

Figure 2. Number of articles per journal