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Winning Combinations: Search Stretegies and Innovativeness in the UK

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Abstract
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for innovation. Extending theories of innovative search, we examine the effectiveness of different bundles of knowledge sources for innovative performance. We suggest that combinations involving ambidextrous knowledge source combinations ? which combine internal and external knowledge ? have greatest likelihood of generating product and process innovation. However, we find important differences between product and process innovation, with the former associated with broader searches than the latter. We also detail how the inclusion of particular sources ? internal, suppliers, customers and universities ? within different bundles is associated with a higher likelihood of innovation outcomes. In this context, we put forward the idea that cognitively distant knowledge sources are only helpful for innovation, when used in conjunction with knowledge sources that are closer to the focal firm. Using a large-scale pooled sample of UK firms we find overall support for our conjectures.

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WINNING COMBINATIONS:

SEARCH STRATEGIES AND INNOVATIVENESS IN THE UK

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ABSTRACT: The search for the most rewarding sources of innovative ideas remains a key area in the management of technological innovation. Yet little is known about which combinations of specific internal and external knowledge sources are triggers for innovation. Extending theories of innovative search, we examine the effectiveness of different bundles of knowledge sources for innovative performance. We suggest that combinations involving *ambidextrous knowledge source combinations* — which combine internal and external knowledge — have greatest likelihood of generating product and process innovation. However, we find important differences between product and process innovation, with the former associated with broader searches than the latter. We also detail how the inclusion of particular sources — internal, suppliers, customers and universities — within different bundles is associated with a higher likelihood of innovation outcomes. In this context, we put forward the idea that cognitively distant knowledge sources are only helpful for innovation, when used in conjunction with knowledge sources that are closer to the focal firm. Using a large-scale pooled sample of UK firms we find overall support for our conjectures.

KEYWORDS: Innovation, organizational ambidexterity, openness, innovative performance.

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INTRODUCTION

Fundamental to the well-functioning of organizations is how effectively they are able search for solutions to the problems they face in their environments. One important set of problems faced by firms are those related to the innovation process. The innovation process is essential to the performance of firms as the ability to innovate is critical for gaining and sustaining competitive advantage (Dierickx and Cool, 1989; McEvily and Chakravarthy, 2002; Nelson and Winter, 1982; Teece et al., 1997; Zott, 2003). In conceptualizing innovations as "combining materials and forces differently", Schumpeter (1912/34: 65) not only positioned innovation at the heart of management and economics, but also linked it intrinsically to combinatorial search. Subsequent advances provided the central insight that knowledge is unequally and widely distributed amongst individuals, and that a central challenge in society is to find new ways to access and productively combine this knowledge (Hayek, 1948). More recently, scholars have suggested innovation models (e.g., Fleming and Sorenson, 2004; Hargadon and Sutton, 1997; Katila and Ahuja, 2002; Kogut and Zander, 1992; Laursen and Salter, 2006) where innovation is seen as a result of a search process resulting in the novel integration of previously separate bodies of knowledge.

However, while models of combinatorial search have greatly enhanced our understanding of the underlying processes, as Rothermel and Alexandre (2009) point out, very little empirical research has been undertaken into the effect of combinatorial search processes across organizational borders on firm performance. In this paper, we examine the effectiveness of combinatorial search using different sources of innovation — such as internal research and development, competitors, customers, suppliers, universities etc. — on the probability that given combinations will be associated with a higher probability that an organization will be able to innovate. Previous research on sources of innovation has highlighted the interactive character of the innovation process, suggesting that organizations rely heavily on their interaction with actors outside the boundary of the focal firm including lead users, suppliers, and a range of institutions inside the innovation system (Chesbrough, 2006; Fey and Birkinshaw, 2005; Laursen and Salter, 2006; Lundvall, 1992; Sammarra and Biggiero, 2008; von Hippel, 1988; von Hippel, 2005). Despite considerable research into the importance of particular sources for innovation (see for instance, Bierly et al., 2009; Klevorick et al., 1995; Sobrero and Roberts, 2001; Spencer, 2001; von Hippel, 2005), little is known about what combination of specific knowledge sources is most conducive to innovation. Given the importance of sourcing knowledge for achieving higher innovative performance, the lack of information on the "winning combinations" of sources represents a critical gap in our understanding of the innovation process. In this context, we define "winning combinations" as configurations of sources of knowledge that have the effect of increasing the probability of firms being innovative in terms of process or product innovation, over alternative configurations.

Drawing on the literature on ambidextrous organizations (e.g., Rothaermel and Alexandre, 2009; Tushman and O'Reilly, 1996), theoretically we suggest that ambidextrous sourcing strategies are associated with better innovative performance than search approaches that focus on internal or external sources. Given that the use of internal and external sources of innovation is costly, we also propose that a very broad external search is associated with a lower propensity to innovate. Moreover, we hypothesize that there are important differences between product and process innovation, with the former associated with broader searches than the latter. We also detail how the inclusion of particular sources — suppliers, customers and universities — within a combination, should be associated with a higher likelihood of innovation outcomes. We put forward the idea that successful combinations resulting in process innovation needs use suppliers as a source, while for product innovation, successful combinations should involve customers as a source. Regarding universities as a source of innovation, we conjecture that given the distance of university knowledge from commercial practice, it will only be part of a successful combination, when combined with other more "close" knowledge sources (such firm-internal, suppliers and customers), as these knowledge sources allow for repackaging and translation of university knowledge.

Our empirical analysis exploits data on manufacturing and service firms from two waves of the UK Innovation Survey, covering over 6,690 firms. We explore how the use of different combinations of sources — what we call a firm's search strategy — shapes innovativeness in subsequent years. By and large we find support for our theoretical suggestions.

In terms of originality, our contribution theoretically extends the concept of combinatorial search to include combinations (or "configurations") of specific internal and external sources of knowledge, helping to deepen and extend our understanding of ambidextrous sourcing strategies (Bierly et al., 2009; Rothaermel and Alexandre, 2009). In this context, Rosenkopf and Nerkar (2001) address the issue of firm-internal sourcing versus inter-organizational boundary-spanning in the context of innovation, but they do not distinguish different types of external knowledge sources. Bierly et al. (2009) deal with the issue of the relationship between firm capabilities, on the one hand, and exploration and exploitation in terms of external knowledge sourcing, on the other hand, in the context of university research centers. However, Bierly et al. (2009) only address one specific external knowledge source. Rothaermel and Alexandre (2009) explicitly address the issue of ambidextrous knowledge sourcing across organizational boundaries in the sense of firm-internal knowledge sourcing and firm-external knowledge sourcing. Although they look at the percentage of external knowledge sourcing over total external knowledge sourcing, they do not distinguish different types of external knowledge sources. We suggest that a notion of search strategies involving *ambidextrous knowledge source combinations* can further our understanding of this phenomenon as it explicitly allows for the fact that external knowledge sources are heterogeneous. We investigate the implications of the use of different combinations of internal and external sources for the probability of being an innovator, helping to uncover what types of search efforts provide the greatest reward to managers. In this context, we investigate the idea that cognitively distant knowledge sources are only helpful regarding innovation, when used in conjunction with knowledge sources that are closer to the focal firm. Second, we contribute to the innovation literature by arguing — and empirically substantiating — that focusing on single sources of innovation is potentially destructive. Rather, it is combinations of multiple sources that drive firm innovativeness. Finally, we propose an important empirical contribution as we propose a methodology for testing specific combinations of sources of innovations.

THE SEARCH FOR INNOVATIONS

Innovative search can be defined as "an organization's problem-solving activities that involve the creation and recombination of technological ideas" (Katila and Ahuja, 2002: 1184). The search for new combinations often requires firms to work with many different actors outside the firm, including consultants, customers, suppliers and universities (Lundvall, 1992; Nelson, 1993; Spencer, 2003; von Hippel, 1988). These search processes oblige firms to expend considerable efforts to build relationships and understanding to absorb knowledge from external sources (Cohen and Levinthal, 1990; Zahra and George, 2002) and to build the capabilities to understand the routines, norms and habits in the ways that different actors work (Brown and Duguid, 2000). Thus, search requires investment in the formation of networks and social capital (Hagedoorn and Duysters, 2002; Powell et al., 1996). For example, Rosenberg (1990) describes investment in basic research as a "ticket to an information network", allowing firms to search more effectively and to build relational capital with external sources. Von Hippel (1988) describes the dense patterns of interactions that take place vertically (i.e. between firms and their customers, and between firms and their suppliers), as well as horizontally (i.e. with competitors through informal knowledge trading). In addition, numerous studies have demonstrated the importance of interaction between firms and universities and/or academic research in the generation of innovations (Ambos et al., 2008; Cohen et al., 2002; Henderson et al., 1998; Laursen and Salter, 2004; Mansfield, 1991; Markman et al., 2008).

To date, there are a number of empirical studies that have assessed the character and impact of search strategies on innovation. For instance, Stuart and Podolny (1996) find that firms search in areas technologically close to their existing patent portfolio. Fleming and Sorenson (2004) focus on the impact of science on subsequent technological development, finding that patents drawing from science are likely to increase the likelihood of new combinations in subsequent search activities. Katila and Ahuja (2002) investigate the impact of search depth and scope on innovative performance, and find that sometimes firms "over search" and that this has negative performance implications. Katila (2002) shows how firms' search into past knowledge influences their future innovative performance. These studies tend to focus, however, on search within a technological trajectory as measured by patent citations. In this respect, patent citations are imperfect measures of innovative search because they focus only on searches within a technological area, and may reflect both technological similarities and search activities. Moreover, a considerable number of the citations in patents are inserted by patent examiners and not by inventors (Alcacer and Gittelman, 2006; Criscuolo and Verspagen, 2008; Thompson, 2006). These studies also tend to focus on single sources of knowledge (such as science/universities) and therefore say little about innovative searches across different sources of knowledge.

HYPOTHESES

In the search for innovations, firms face a wide array of choices. Drawing on well established internal knowledge may facilitate exploitation, because such knowledge is likely to accessible, easily convertible and well aligned to the capabilities of the organization (March, 1991). Indeed, given lower search costs, there are numerous advantages to local search inside the organization (Helfat, 1994). By focusing on internal sources, firms ensure that the knowledge they use in the innovation process is safe, well established and understood by its managers. Moreover, relying on internal sources may also lower the managerial resources required for innovation as the coordination costs of learning about, and transferring, internal knowledge is less than the case for external knowledge (Szulanski, 1996).

However, the problem with local sources of inputs is that they often offer too little inspiration and variety for problem solution with respect to innovation-related problems — the local search environment may not provide enough prospects for the combination and recombination of knowledge (Fleming and Sorenson, 2004; Rosenkopf and Nerkar, 2001). A focus on adopting more "open" search processes in order to find new combinations of knowledge and technology may be part of the firm's solution to this challenge. One example of work along these lines is Chesbrough's (2003; 2006) open innovation model. Chesbrough argues that there has been a decline in the strategic advantage of internal R&D and that firms need to engage in broader search processes, which may include drawing knowledge from multiple actors outside the boundaries of the organization. Several large firms, such as Procter & Gamble, IBM and Philips, have adopted this model to some extent (Dodgson et al., 2005; Sakkab, 2002).

Despite a spate of managerial books suggesting that firms need to move toward more open models of innovation, many firms find engaging in external sources of knowledge is simply too difficult to manage, and instead they rely primarily on internal knowledge sources (Laursen and Salter, 2006). Certainly — as argued above — external knowledge may offer greater returns, but it may be harder to access, difficult to transfer and discordant with internal practices and capabilities (Rothaermel and Alexandre, 2009). Moreover, the decision to use internal sources, or what might be called the “go-it-alone” search strategy, may reflect a “Not-Invented-Here” syndrome, where managers turn away from potentially useful external ideas as they diverge from internal efforts (Katz and Allen, 1982). This approach, however, may lead the organization to forgo opportunities to capture external knowledge, but also hinder the effectiveness of internal projects as solutions to problems that emerge within these projects may not be available within the organization. Accordingly, this “go-it-alone” approach could lead a firm to miss out on productive new combinations of both internal and external knowledge.

In contrast, a search strategy based purely on the use of external sources — a case of extreme openness or a “go-all-out” strategy — could have the advantage of facilitating exploration, opening up new areas of discovery distant from a firm’s own knowledge base (March, 1991). These external sources may work in new areas that are removed from the current practices and products of the firm. They may also provide opportunities to learn from users and developers of technology that differ from the firm’s own experience (von Hippel, 2005). Some firms may be attracted to the low cost and potential high rewards associated with new open models of innovation and think that external sources can provide an effective substitute for internal investments, allowing them to “outsource” the innovation process (Rigby and Cook, 2002). Along these lines, Menon and Pfeffer (2003) argue that at times managers may exhibit a strong preference for external knowledge as this knowledge is perceived to be more scarce and hence more valuable than internal knowledge. However, this “go-all-out” approach could lead to lack of integration between the internal efforts of the firm and its external sources. Knowledge and ideas from these sources may be poorly utilized and not translated into successful outcomes, as they may be too distant and discordant from what the organization already knows and can do (Levinthal and March, 1993). Accordingly, external sources may offer the allure of novelty, but such novelty will only be of value if it can be successfully applied to the firm's own knowledge base.

Fundamentally, innovation is likely to require the successfully integration of both internal and external sources of knowledge. Those firms that are able to find a good fit between internal and external sources are likely to exhibit higher performance than those firms who search simply along internal or external pathways (Bierly et al., 2009; Rothaermel and Alexandre, 2009). Accordingly, we propose that firms that adopt *ambidextrous sourcing combinations* (which combine knowledge from internal and external sources) are likely to have a higher success rate with respect to process and product innovation. Such a strategy will ensure that there is an alignment between internal and external search efforts and that knowledge that is captured from external sources will be matched to internal capabilities. This bundling of external knowledge to internal search processes will be complementary (i.e. mutually reinforcing, see, Arora and Gambardella, 1990; Cassiman and Veugelers, 2006) as it helps to optimize both internal search efforts by providing insights and resources that are not held internally, but could also increase the effectiveness of external search by directing these search efforts towards productive sources. Thus,

> *H1 Firms that engage in ambidextrous knowledge sourcing will have a higher likelihood of innovating than firms that rely on either external or internal sources alone.*

The implications of concepts of combinatorial search in the literature on innovation suggest that firms that bring together and harness diverse sources of knowledge are more likely to develop and commercialize new ideas. Developing an innovation may require firms to bring together knowledge from a range of different sources, and by recombining this knowledge, firms will be able to see opportunities to re-use existing knowledge in new settings, as well as to combine new knowledge with existing knowledge (Hargadon and

Sutton, 1997). This process of recombination often involves brokering knowledge from domains where it is common, to those where it is novel (Burt, 2004). Brokering requires that a firm is alert to the opportunities afforded by recombination, and drawing from a diverse range of sources is a strong signal that a firm has developed the “bandwidth” to exploit diverse opportunities from its external environment (Burt, 2005). Accordingly, search strategies that recombine complementary knowledge from a range of sources are likely to exhibit greater opportunities for innovation than more narrowly-based search strategies. As an example, sourcing knowledge from universities may in many cases be useful, or even crucial, for successful innovation. However, without additional knowledge from users concerning the conditions under which the innovation—perhaps in the form of a new piece of equipment—will operate, it may suffer from a number of severe limitations. Thus,

H2a Firms that undertake broad combinatorial search are more likely to be innovative than those firms focusing on narrow search strategies

Notwithstanding the benefits of a broad search for innovation described above, there are also costs associated with searching. First, broad search strategies, which involve combining knowledge from a wide range of sources, may require high levels of managerial attention and resources to execute effectively (Ocasio, 1997). This is because each search channel itself may require relation-specific investments, and therefore firms will have to invest their resources in building capacity to absorb knowledge from each of these different sources (Laursen and Salter, 2006). Such investments may require considerable external monitoring, the creation of dedicated scouting staff, staff training in working with externals, corporate investments in universities, and the like. It is not clear that the costs of additional knowledge sources equal their benefits in terms of generating innovations, when the number of sources is already substantial: Using an additional external source in this situation is unlikely to be as be beneficial as the initial sources. Second, brokering knowledge between different sources of knowledge may be difficult when the cognitive distance between these sources are great (Nooteboom, 2000). Since knowledge developed by different external sources may be divergent in content and organization, the firm may find that the cost of combining these diverse sets of knowledge is high relative to the returns gained by the effort. These two factors suggest that there are likely to be diminishing returns to combinatorial search and that firms that engage in very broad combinations will be less able to innovate than firms that adopt more balanced approaches to combinations of sources. Thus,

H2b Firms that undertake very broad combinatorial search are less likely to be innovative than those firms having broad search strategies

In studies of innovation sources, it is common to highlight the differences between product and process innovation (Damanpour and Gopalakrishnan, 2001; Tushman and Anderson, 1986; Utterback, 1994). Product innovation involves the creation of technologically new products, whereas process innovation can be defined as new elements introduced into an organizations' operations and production process — the work flow, materials and tasks, which are underpinned by information management and capital equipment — with the aim of lowering costs and/or creating greater product quality (Freeman and Soete, 1997; Rosenberg, 1976; Utterback, 1994). Product innovations often arise through interactions with lead users, universities and other key sources of innovation (von Hippel, 1988). Product innovation requires extensive processes of exploration, interaction and orchestration of many different internal and external sources of knowledge (Brown and Eisenhardt, 1995). In contrast, process innovation has been described by Tushman and Rosenkopf (1992) as "the most primitive form of innovation". Process innovations are often the result of firm-internal learning-by-using and learning-by-doing, arising from organizations' experience in using new technology (Hatch and Mowery, 1998; Rosenberg, 1982). Accordingly, process innovations are strongly determined by managerial decisions about how best to organize the firm to maximize the efficiency and effectiveness of its internal procedures, routines and operations (Damanpour and Gopalakrishnan, 2001; He and Wong, 2004; Jansen et al., 2008). Accordingly, process innovation is more exploitative and appears to require less external search than product innovation. However, the use of external sources of innovation may continue to be beneficial for process innovation because central external sources, such as suppliers, might be responsible for the key inputs required to implement new processes. For example, the use of lean production often requires firms to develop new relationships with suppliers and to draw on them for knowledge about production and delivery times (Womack et al., 1990). Nevertheless, given the smaller number of knowledge inputs required for process innovation compared to product innovation, the nature of these relationships is likely to be narrower and more confined. In sum, we suggest that firms that achieve a process innovation are likely to use fewer sources of innovation than firms that achieve product innovation. Thus,

> *H3. Process innovation is likely to be associated with narrower search strategies than product innovation.*

Although the above hypotheses explore the advantages and disadvantages of different forms of combinatorial search, they say little about the importance of individual sources of knowledge within these combinations. It is clear, however, in the literature on innovation that there are critical external sources of knowledge that are associated with greater innovation outcomes. One of the most important is the role of suppliers in shaping process innovation (Pavitt, 1984; von Hippel, 1988). The ability to develop process innovations often requires manufacturers to work closely with suppliers of specialized machinery. Process innovations often must draw out new types or combinations of technology from their suppliers. Suppliers themselves can also act as a spur for process innovation, as new components and technology may allow user firms to reshape their production processes. Indeed, there is strong feedback between technologies and components available from external suppliers and the potential for firms to achieve a process innovation. In sum, we conjecture that:

Hypothesis 4a: Process innovation will be associated with search strategies that involve drawing knowledge from suppliers.

As mentioned earlier, newer models of innovation highlight the critical role of users[1] in shaping the potential of firms to achieve product innovations. von Hippel (2001; 2005) describes the central importance of users in drawing out new products from manufacturers, since users may provide a rich tapestry of experience and ideas about how to improve existing products and even the spur for the creation of new products. Certainly, in many cases, users are the first to experience the need for a new product and they may also frequently have the incentive to contribute with knowledge and user experience given that they will be the first to benefit from the existence of a product innovation (von Hippel, 1988). Thus, we infer that:

Hypothesis 4b: Product innovation will be associated with search strategies that involve drawing knowledge from customers.

In the generation of innovative ideas, universities can often be a critical source of knowledge for private firms (Jaffe, 1989; Zucker et al., 1998). Research has shown that firms can look to universities to help ensure that internal ideas are successfully delivered (Cohen et al., 2002). In this case, drawing knowledge from universities may allow the firm to access skilled problem-solvers and experts as well as specialized equipment and instruments (Meyer-Krahmer and Schmoch, 1998). However, universities and their faculty operate within a different incentive system than commercial firms, with strong norms for generating new knowledge and publishing of this knowledge in order to establish priority (Dasgupta and David, 1994). As stated by Ambos et al. (2008: 1425): “At its heart, the challenge essentially

[1] In this paper we use the term “users” interchangeably with “clients & customers”, although we are aware that “users” is broader than clients & customers.

involves taking an organization that is equipped for and accustomed to doing one thing (academic research) and at the same time asking it to build a capacity for doing something entirely different (commercialization of technologies and ideas).” While the differences in norms, values and ways of communicating make the use of university knowledge cumbersome for commercial firms when attempting to innovate, such use also creates a unique opportunity to learn about the research frontier, discovering bodies of knowledge that may be distant from their own current experience and knowledge (Bierly et al., 2009; Nelson and Rosenberg, 1994).

Arguably, knowledge sources residing inside the focal firm or among entities that work in a similar commercial environment and have broadly aligned incentives with the focal firm (such as customers or suppliers) represent knowledge that is more cognitively “close” (i.e., “more exploitive”) to the focal firm in comparison with more cognitively “distant” (i.e., “more explorative”) university knowledge. The key point here is that while university knowledge is potentially valuable for commercial firms, it is produced in a very different context and, as a result, it needs to be translated, repackaged and honed before it can be grafted onto the firm’s innovation processes. We posit that this translation process requires combinations with other, more proximal, knowledge sources that are linked tightly to the needs of the focal firms’ immediate environment. In other words, university knowledge is unlikely to be valuable *per se*, unless it is combined with more proximate knowledge. Accordingly, we suggest:

> *H4c. Product and process innovation will be associated with search strategies that involve drawing knowledge from universities, but only when this type of knowledge is combined with other types of internal and external knowledge.*

METHOD

Data and Sample

The goal of our empirical analysis is to determine which combination of different knowledge sources has a stronger effect on firms' likelihood of introducing a new product or process innovation. To examine this we have used data from two consecutive waves of the UK innovation survey conducted in 2005 and 2007. In particular, data on our dependent variables are taken from the latest survey while data for our independent and control variables come from the earlier survey. Using diverse sources of data for the dependent and independent variables allows us to avoid common-method bias that can "arise from a common rater, a common measurement context, a common item context or from the characteristics of the items themselves" (Podsakoff et al., 2003: 886).

The UK innovation surveys are carried out by the Office of National Statistics (ONS) on behalf of the Department of Business, Innovation and Skills (formerly the Department of Trade and Industry - DTI). The UK Innovation Survey is part of the fourth European-wide Community Innovation Survey (CIS) (Robson and Ortmans, 2006). The implementation of these surveys, the type of questions and the sampling techniques, follow the guidelines described in the Organisation for Economic Co-operation and Development's (OECD) Oslo Manual (OECD, 2005). The CIS are often described as "subject-oriented" because they focus on the innovating agent rather than on the technology (Archibugi and Pianta, 1996). CIS data provide a useful complement to the traditional measures of innovation output, such as patent statistics (Cassiman and Veugelers, 2006; Leiponen and Helfat, 2010b; Mairesse and Mohnen, 2002), as they cover a wider range of industries, including services, and different types of innovative outputs, such as product and process innovation (Leiponen and Helfat, 2010a).

The UK innovation surveys cover many different aspects of the innovation process. Firms are asked to report on whether they have achieved a product and/or a process of innovation during the two year period before they received the questionnaire, with product innovation defined as "the market introduction of a new good or service or a significantly improved good or service with respect to its capabilities, such as quality, user friendliness, software or subsystems", and process innovation defined as "the use of new or significantly improved methods for the production or supply of goods and services" (DTI, 2005). The surveys also contains questions on other innovation related activities such as the source of information relevant to innovation, whether they received government funding to carry out innovation activities, whether they engaged in technological collaboration, and how much they spend on R&D. The validity of the CIS questionnaire has been established through a series of pilot studies and pre-testing before implementation in different European countries and in a number of industries, including manufacturing, services and construction (Smith, 2005).

The 4th UK survey was mailed in 2005 to sample of 28,000 firms with 10 or more employees both in the manufacturing and services sectors. The survey respondents were generally the firms' Managing Directors, Chief Financial Officers or R&D managers. A total of 16,240 firms took part in the survey, which corresponds to a response rate of 58 percent. This high response rate greatly limits the potential for non-response bias (Armstrong and Overton, 1977: 396). The sample of firms was created by the ONS using stratified random sampling for firms below 250 employees, stratified across 23 sectors, 12 regions and size bands. All firms with more than 250 employees were included in the sample. The 5th UK Innovation Survey was sent to 28,000 firms in 2007 to the same set of firms and achieved a response rate of 53%. Because the sample population was the same across the two surveys when we matched the firms in the 4th UK Innovation Survey with information on those firms in the 5th UK Innovation survey, we were able to achieve quite a large overlap sample of 6,693 firms across the two surveys.

Although the size of the matched sample is relative large, there is still the possibility that the data used in our analysis suffers from sample selection bias. We checked for this by testing whether the distribution of the main firms' characteristics could affect their innovative performance, such as size, age, R&D intensity, technological cooperation, reception of government funding supporting R&D investment, and being a corporate venture, differs between the firms that replied to both surveys and those that only responded to the 4th UK Innovation Survey. There was no statistically significant difference between these two groups in terms of all variables with the exception of age. The average age of firms in the overlap sample was 21.8 years compared with 19.8 years for those firms which we could not identified in the 5th UK Innovation survey. This finding could be explained by survival bias. However the correlation between age and our main independent variables, the search strategies, is very low which suggests that although these two samples of firms do differ in terms of their age, they do not necessarily differ in terms of the independent variables of interest in this study.

Measuring Complementarities

The literature on measuring complementarities proposes two approaches: the interaction approach and the systems approach (Ennen and Richter, 2010). In a regression analysis setting, the interaction approach examines the effect of a few variables, typically just two (e.g., Cassiman and Veugelers, 2006). In contrast, the systems approach (e.g., Ichniowski et al., 1997) looks at the relative performance outcomes of entire sets of variables, also in a regression analysis. Both approaches have pros and cons—the interaction approach indentifies complementarities more precisely in accordance with complementarity theory, whereas the systems approach can handle more complex situations with many more variables. Our approach follows the systems approach. However, while authors using the systems approach test a single or a few combinations of (multiple) variables, we specify our model so that we can test many different combinations (26) simultaneously.

Measures

Dependent variables. We use two measures of innovative performance: one referring to product innovation, the other to process innovation. *Product innovation* is measured using an item on the 5th UK Innovation Survey that asked firms whether during the three-year period 2004 to 2006 they had introduced any technologically new or significantly improved product (goods or services). *Process innovation* is measured in a similar way, using an item on the questionnaire that enquired whether firms had used any new or significantly improved technology for production, or for the supply of products (goods or services), during the period 2004 to 2006. These variables are equal to 1 if the firm introduced a new product or a new process, and 0 otherwise. Similar variables have been used by, for instance, Love et al. (2009), Reichstein and Salter (2006), and Leiponen and Helfat (2010a).

Independent variables. Search strategies in terms of knowledge source combinations are measured using responses to the 4th UK Innovation Survey assessing the importance — on a four-point scale — of six sources of knowledge for firms' innovative activities: internal to the firm, suppliers & consultants, customers, competitors, and universities & other research institutes. These knowledge sources listed in the survey broadly correspond with the resources and institutions that are considered part of the national innovation system (Lundvall, 1992; Spencer, 2001) and these sources have been included in numerous earlier empirical studies (e.g., Grimpe and Sofka, 2009; Laursen and Salter, 2006; Leiponen and Helfat, 2010a; Leiponen and Helfat, 2010b). The responses to these questions are converted into binary variables (1 if the source is of medium or high degree of importance and 0 if the firm does not use the specific source or evaluate it as having a low degree of importance).

This produces 32 (2^5) possible distinctive innovation search strategies characterized by some combination of external and internal sources of knowledge. To secure the reliability of the econometric estimations, we consider only strategies adopted by 12 or more firms, since the inclusion of less common strategies implies relying on only a few observations. This reduces the number of strategies under scrutiny to 26. Table 1 displays the different search strategies and the number of firms that have adopted them ordered according to the type of search strategy, i.e. *internal only, external only, and ambidextrous*, and to the number of knowledge sources within them.

Control variables. We control for firm size and to whether the firm undertakes R&D activities since these variables frequently have been identified as factors that can influence innovation performance (Cohen, 1995; Kleinknecht, 1996). *Firm size* is measured as the number of employees in full-time equivalents (expressed in logarithms) in 2004. The extent of firms' R&D efforts is captured by two items in the survey: *R&D investment*, which is equal to 1 if the firm undertook activities aimed at increasing the stock of knowledge and its use to create new or improved products or services during the period 2002-2004; and the *share of scientists and engineers* as a proportion of the total number of employees in 2004. Another important firm characteristic that has found to be correlated with firm innovative performance is age (Sorensen and Stuart, 2000). We use the data from the Inter-Departmental Business Register, which covers all UK businesses registered for value added tax purposes, to measure the *firm age* in years. We also include a dummy variable about whether the firm is part of a larger organizational group (*Corporate Venture*), which is equal to 1 if the firm belongs to an enterprise group and whether firm is domestic owned (*Domestic*) using the data from the Inter-Departmental Business Register. In addition, we introduce a variable to control for the size of the perceived product market (*Market Focus*). This variable is measured using a 1-4 items on the questionnaire that asked firms to indicate which of four markets (local, national, European, or beyond Europe) they perceive to be the largest for their products. This variable therefore should control for the fact that, as shown by MacGarvie (2005), firms operating in the international market tend to be more innovative. Additionally, we include a binary variable measuring *innovation co-operation* that controls for whether or not firms have engaged in R&D co-operation with other firms or institutions. Previous studies have found a relationship between co-operation and innovative performance (Powell et al., 1996; Ahuja, 2000; Cassiman and Veugelers, 2002). Literature on publicly funded R&D (Griliches 1995) suggests that government support for R&D in the form of tax credits, deductions, grants, or subsidized loans, can have a positive and significant effect on the firm's innovative performance by increasing investment. We account for this by including a dummy variable (*Government Funding*) equal to 1 if, during the period 2002-2004, the firm received public financial support for innovation from either regional, national or European authorities. Finally, we include 7 industry dummies to account for difference in propensity to innovate across industries (Klevorick et al., 1995).

Econometric method

Our dependent variables are binary variables thus a logit or a probit model would be the appropriate econometric estimation procedures for explaining the impact of search strategies on the probability of introducing a new product or a new process. However, if we were to estimate two separate probit or logit models one for the incidence of product innovation and one for the incidence of process innovation, we would implicitly assume that the two innovative outcomes are completely independent from each other. This is a strong assumption, which is not consistent with the findings of a number of empirical studies showing that product and process innovations are interdependent (Damanpour and Gopalakrishnan, 2001; Martinez-Ros, 2000; Pisano, 1997; Reichstein and Salter, 2006). One way to relax this assumption is to simultaneously model the two innovative outcomes using a bivariate probit model (for a recent application of this model in the context of product and process innovation, see, Hall et al., 2009). This model is an extension of the probit model, which allows for correlation between the error terms of the equation modeling the likelihood of product innovation and the one modeling the likelihood of process innovation. Such correlation recognizes that product and process innovations are likely to be influenced by common unobservable factors. Thus, the bivariate probit jointly explains product and process innovation using the same set of variables as regressors, although it allows for their impacts to differ across the two equations.

Results

Table 1 shows the distribution of the search strategies. Although the most popular strategy is not to engage in any search activity, we find that many firms search broadly by combining both internal and external sources of knowledge. Indeed, ambidextrous search strategies are much more common than strategies involving only internal or external sources of knowledge. It is interesting to note that strategies that rely only on one source of knowledge — whether internal or external — are less popular than strategies comprising multiple sources, suggesting that most firms seek to combine knowledge from a range of sources. The most popular search strategy involves internal, suppliers, competitors, and universities, while the least used is a strategy where firms source knowledge from only suppliers and universities.

<Insert Table 1 about here>

Table 2 summarizes the descriptive statistics of the variables included in the model. Almost one quarter of the firms are product innovators, while 15% are process innovators. In our sample, more than one third are corporate ventures and a similar number of foreign owned firms. Almost 28% of firms have invested in R&D and 15% of them were engaged in innovative collaborative agreements during the period 2002-2004. Table 3 reports the correlation matrix. In terms of the correlation coefficients, we have no reason to suspect multicollinearity problems as none of the coefficients are high.

<Insert Table 2 about here>

<Insert Table 3 about here>

Table 4 shows the coefficient estimates of the bivariate probit.[2] Before commenting on the results, we note that the estimated correlation coefficient of the error terms is always positive and significant, which indicates that product and process innovations are influenced by a common unobservable factor and that it is important to simultaneously model product and process innovation outcomes. Thus, the bivariate model appears a highly appropriate estimation method.

<Insert Table 4 about here>

The first two columns of Table 4 show the estimates of our baseline, model which includes only the control variables. Coefficients from this model are consistent with previous findings in the innovation literature and most importantly they do not significantly vary in magnitude and significance when we include our main independent variables.

The last two columns of Table 4 report the results of our full model. One interesting finding, which will be investigated further in the following tables, is that strategies involving suppliers appear more likely to lead the firm to become a successful process innovator than to become a product innovator. For example the search strategy, which relies only on suppliers as a source of knowledge, is positive and statically significant at 1% in the process innovation equation, but not in the product innovation equation (note that this finding is consistent with hypothesis 4b; for further discussion of this hypothesis, see below). Similarly the strategy involving suppliers and competitors and the one using suppliers and universities have a positive and significant impact on the likelihood of process innovation, but they have a no significant effect on the probability of introducing a product innovation. The other interesting pattern emerging from our results is that strategies employing a higher number of knowledge sources are more likely to improve chances of innovative success, especially in the form of a new product (note that this finding is consistent with hypothesis 2a; for further discussion of

[2] Results from the corresponding probit models are reported in Table A1 in the appendix.

this hypothesis, see below). Finally, by examining the magnitude of the coefficient estimates, we note that the strategy most conducive to product innovation is the one drawing on customers, universities and internal sources of knowledge, while the strategy with the greater impact on the likelihood of a process innovation is the one using suppliers and universities.

However, to be able to identify the winning strategies for each of the innovation outcomes, we need to test each of the coefficient estimates against the others. The results of these *t*-tests are reported in a matrix format in Tables 5 and 6 where we show the coefficient estimates of the bivariate probit next to each search strategy. The stars in each cell indicate significant differences between the strategy in the corresponding column and that in the corresponding row at a 1 percent (***), a 5 percent (**), and a 10 percent (*) level. To simplify interpretation of our findings, we only report the results of a significant *t*-test when the coefficient on the row is greater than the one in corresponding column. This should help identify the winning strategies, those most conducive to either product or process innovation. Thus cells without stars indicate either that the two compared strategies do not have a significant different impact on the likelihood of the innovation outcome or that the strategy in the column has a coefficient estimate, which is statistically significant smaller than the one in the row.

The results of the *t*-tests confirm that the search strategy including internal sources, customers and universities (strategy 21) is one of the strategies most beneficial for product innovation. Another strategy, which is as beneficial as strategy 21 and with a higher impact on the likelihood of product innovation than many other strategies, is strategy 25, which involves internal sources, costumers, competitors and universities. As might be expected, using customers as a knowledge source seems to be critical for successful product innovation. However, the use of customers alone does not appear to lead the firm to become a product innovator. Indeed, our results suggest that strategies employing one search channel, whether external or internal to the firm, are less likely to lead to improved chances of innovative success, indicating combinatorial strategies outperform single source approaches.[3] In general, the findings suggest that combinations involving both internal and external knowledge sources are more conducive to product innovation than strategies only comprising of external sources of knowledge. Indeed, the results are consistent with Hypothesis 1, indicating the advantages for innovation in the use of ambidextrous sourcing strategies.

The results in Table 5 show that the search strategy drawing on internal sources, suppliers and customers (strategy 17) is significantly more likely to lead the firm to become a successful product innovator than strategies 1, 2, 3, 5, 6, and 16. However, the impact on the likelihood of product innovation of pursuing this search strategy is not statistically different or greater than all the remaining strategies. These results provide some evidence for Hypothesis 2a as they suggest that broad combinatorial strategies will outperform on average narrow strategies for both product and process innovation.

<Insert Table 5 about here>

We find partial support for Hypothesis 2b as for both innovation outcomes the strategy using all knowledge sources (strategy 26) is not among the very top strategies. This is especially the case for process innovation. In this instance, it appears that a very broad search strategy provides relatively little return for innovation compared to somewhat more focused search strategies. For product innovation, however, while “all sources” is not among the very best strategies (21 and 25) it does outperform several other combinations.

Hypothesis 3 concerns the differences in the importance of broad combinatorial search for product and process innovation. Overall, the results give support to this view as most of the successful strategies for product innovation are broad ones, whereas for process innovation

[3] We performed a test for equality of coefficients for all strategies including only one search channel and found that we could not reject the null hypothesis (*p*-value= 0.420), i.e. they all the same effect in leading to product innovation. A similar result was found when we test for equality of coefficients for strategies including only one or two search strategies (*p*-value=0.236).

narrow search strategies are not worse than broad strategies. This suggests that process innovation may require less combinatorial novelty as it represents a more modest type of innovative achievement.[4]

<Insert Table 6 about here>

Judging from Table 5, in the case of product innovation, drawing knowledge from customers is often present in a winning combination — in fact customers are involved in all of the most successful strategies (17, 20, 21, 22, 23, 25, and 26). However, by the same token, strategies 3 (customers alone) and 6 (suppliers and customers) are among the worst performing strategies. Nevertheless, overall, the findings tend to be in line with Hypothesis 4a.

When we examine the results of our *t*-tests on the coefficient estimates of the search strategies in the process innovation equation reported in Table 6 we find that the strategy drawing on internal sources, suppliers, customers and universities is among the most effective strategies leading to a process innovation. This strategy has a greater impact on the likelihood of introducing a new process than most other strategies, although its effect is not statistically different or greater than strategies 7, 8, 12, 13, 15, 16, 18, 21, and 24 which, with the exception of strategy 15, all employ suppliers as a search channel. This strongly supports hypothesis 4b stating that drawing on suppliers as a source of knowledge improve the likelihood of being a process innovator.

When exploring the impact of drawing knowledge from universities for innovation, we find little evidence that it is a necessary condition for firms to incorporate universities in their search strategy. Although universities are often (but certainly not always) included within the bundle of sources in the highest performing strategies, they are also present some of the lowest performing strategies. It is also clear that using universities only is the worst strategy

[4] This is confirmed by the fact that when we test for equality of coefficients all strategies including only one search channel we could reject the null hypothesis (*p*-value= 0). Equally we could reject the hypothesis that all coefficients of search strategies employing one or two sources were the same (*p*-value=0).

for both product and process innovation (universities together with firm-internal sources is a poor combination too), indicating that university knowledge by itself offers little advantage to a firm unless it is combined with other external sources. Overall, the results give strong to support Hypothesis 4c.

DISCUSSION AND CONCLUSION

Drawing from arguments about the benefits of combinatorial search from the distributed innovation literature, we have attempted to cast new light on what combinations of knowledge sources provide the greatest inducement to subsequent innovation. In doing so, we have sought to advance understanding about the nature and type of external sources that shape innovative outcomes, extending knowledge of the sources of innovation. In general, the results are consistent with our expectations. We found clear evidence important for firms in adopting strategies involving ambidextrous sourcing combinations, as the amalgamation of internal and external sources of knowledge for innovation seems to strongly facilitate the emergence of innovative outcomes. These results demonstrate that sources of innovation must be viewed as a mutually reinforcing system. In this context, we show that it can be dangerous for firms to rely on a single or a small number of internal or external knowledge sources to spur innovation. Indeed, the go-it-alone (using only internal sources) or go-all-out (using only external sources) strategies were less effective than strategies that blended internal and external knowledge.

Apart from the cognitive problems associated with getting combinatorial search processes right, additional complexity arises in that the type of innovation appears to predetermine which combination offers the highest payoff. This paper shows that the advantages of different search combinations are contingent on the type of innovation being considered. We found important differences between product and process innovation. For example, in product innovation, combining knowledge from internal sources and customers is of central importance, while for process innovation, internal sources and suppliers are key. In general, process innovation requires narrower exploration or exploitation of external sources of knowledge than product innovation, indicating a set of search activities that are more modest in scope and nature than those required for product innovation. These findings support notions of the seminal contribution of particular knowledge sources for different types of innovation. However, when we considered the role of universities in spurring innovation, we found little clear evidence of a direct benefit to firm's innovative outcomes. Although universities were often included in the most successful strategies, they were also present in the least successful strategies. This suggests that benefits of using universities as a source of knowledge, without combining it with other types of external knowledge, are limited. However, in combination with other types of external knowledge, universities appear to be a very valuable source with respect to innovation outcomes.

Our paper makes several contributions to the literature. At a general level, the findings of this paper have implications for the resource-based view of the firm. According to this view, sustained competitive advantages may be attained through ownership of resources that can be considered valuable, rare, non-substitutable, and imperfectly imitable (Barney, 1991). In this paper, we have demonstrated that firms' abilities to innovate — a central determinant of sustained competitive advantage — are affected by their ability to detect combinations of different sources of innovation. Even if resource-based scholars are skeptical of obtaining competitive advantage through firm-external means, the social complexity and the related difficulty involved in getting these combinations of knowledge sources right, a successful combination can be perceived as an additional and important hard-to-imitate resource.

We also contribute to the literature on open and distributed innovation. In this context, we were able to confirm the importance of users — in particular for product innovation — as demonstrated in previous research on the innovation process (see for instance, Urban and von

Hippel, 1988; von Hippel, 2001) — since using customers as a source of knowledge is always involved in winning combinations. Nevertheless, the existing user innovation literature tends to focus on the importance of users *per se* in stimulating innovation, while our findings point to the limitations of applying single sources of innovation. This leads us to a more general point: Rather than assessing the effects of a specific knowledge source for innovation — as is common in the distributed innovation literature — the present study has analyzed the impact of particular *combinations* of knowledge sources.

We also add to the literature on search and ambidextrous organizations. We have extended the part of this literature that addresses inter-organizational aspects by explicitly accounting for the fact that external knowledge sources are of a heterogeneous nature — it is not only a question of how much external knowledge a firm is able to use in its innovation process, it is also of matter of the type of knowledge and how it is combined with other types of knowledge. In this context, we believe that our notion of ambidextrous knowledge source combinations is a useful one. We also added to this literature by showing that searches using cognitively distant knowledge sources are only helpful for innovation, when used in conjunction with search using knowledge sources that are closer to the focal firm.

Our paper has important implications for management. One clear implication is that it is dangerous for managers to attempt to “go it alone” or to “go-all-out” when pursuing innovation. In general, we found support for the idea that openness to external sources is conducive to being innovative. We also found that generally not using any knowledge sources is the worst strategy. In addition, using only internal sources is among the lowest performing strategies. Moreover, it is important for managers to try to develop ambidextrous sourcing strategies, combining internal and external sources of knowledge with respect to both product and process innovation. Our results suggest that firms that do not pay attention to such combinations are less likely to be innovative.

LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Analysis of the performance implications of configurations of complementary sources of knowledge for innovation is a complicated task. Accordingly, simplifying assumptions are required to make the analysis tractable, but caution is required in interpreting the results. The present study was limited to exploring search strategies, and although we include a measure of the use of internal sources, our measure is rather rough in this respect and says little about the way external sources of knowledge are integrated into internal innovation practices (Foss et al., 2011). Given the importance of internal practices in shaping the ability of firms to be innovators, this omission qualifies our findings. A second limitation of the study is related to the dependent variable. The innovator vs. non-innovator distinction can be overemphasized, as many firms are able to live on past innovations or may be able and keen to innovate in the future. Although our lagged structure of measuring innovativeness and search helps to mitigate this concern, it does not remove it. Lastly, by comparing the performance of the most common search strategies only, we missed other less common combinations that may themselves be highly advantageous for innovative performance. In doing so, we were able to find the winning combinations among the most common strategies and not necessarily the winning combinations in general.

This study suggests several lines of further research. In this paper, our dependent variable only states whether or not the firm was able to develop a new product or process innovation. Future research could analyze whether the choice of search strategies influences the degree of novelty or “radicalness” of the innovations. Future research could also attempt to identify potential complementarities between individual sources to explore whether the use of one particular source increases the potential of using another source. This approach might provide insights into which factors drive firms to follow combinatorial search strategies. It may also be possible to explore whether local search strategies are associated with exploitation and maximizing short-term performance, and whether these efforts, in turn, may undermine the exploration, innovation and long-term performance. Using the lens of combinatorial search may help to reveal how the balance between exploration and exploitation shifts over time and how these shifts shape business performance.

REFERENCES

Alcacer, J., and Gittelman, M. (2006). 'How do I know what you know? Patent examiners and the generation of patent citations'. *Review of Economics and Statistics,* **88**, 774-79.

Ambos, T., Mäkel, K., Birkinshaw, J., and D'Este, P. (2008). 'When Does University Research Get Commercialized? Creating Ambidexterity in Research Institutions'. *Journal of Management Studies,* **45**, 1424-47.

Archibugi, D., and Pianta, M. (1996). *Innovation surveys and patents as technology indicators: the state of the art*. Paris: OECD.

Armstrong, J. S., and Overton, T. S. (1977). 'Estimating non-response bias in mail surveys'. *Journal of Marketing Research,* **14**, 396–402.

Arora, A., and Gambardella, A. (1990). 'Complementarities and external linkages: the strategies of the large firms in biotechnology'. *The Journal of Industrial Economics,* **38**, 361-79.

Barney, J. B. (1991). 'Firm Resources and Sustained Competitive Advantage '. *Journal of Management* **17**, 99-120.

Bierly, P., Damanpour, F., and Santoro, M. D. (2009). 'The application of external knowledge: Organizational conditions for exploration and exploitation.'. *Journal of Management Studies,* **46**, 481-509.

Brown, J. S., and Duguid, P. (2000). *The social life of information*. Boston, Massachusetts: Harvard Business School Press.

Brown, S. L., and Eisenhardt, K. M. (1995). 'Product development: Past research, present findings and future directions'. *Academy of Management Review,* **20**, 343-78.

Burt, R. S. (2004). 'Structural holes and good ideas'. *American Journal of Sociology,* **110**, 349-99.

Burt, R. S. (2005). *Brokerage & Closure: An Introduction to Social Capital*. Oxford: Oxford University Press.

Cassiman, B., and Veugelers, R. (2006). 'In Search of Complementarity in Innovation Strategy: Internal R&D and External Knowledge Acquisition'. *Management Science,* **52**, 68-82.

Chesbrough, H. (2003). *Open innovation*. Cambridge, Massachusetts: Harvard University Press.

Chesbrough, H. (2006). *Open Business Models: How to Thrive in the New Innovation Landscape*. Boston: Harvard Business School Press.

Cohen, W. M., and Levinthal, D. A. (1990). 'Absorptive capacity: A new perspective of learning and innovation'. *Administrative Science Quarterly,* **35**, 128-52.

Cohen, W. M., Nelson, R. R., and Walsh, J. (2002). 'Links and Impacts: The Influence of Public Research on Industrial R&D'. *Management Science,* **48**, 1-23.

Criscuolo, P., and Verspagen, B. (2008). 'Does it matter where patent citations come from? Inventor vs. examiner citations in European patents'. *Research Policy,* **37**, 1892–908.

Damanpour, F., and Gopalakrishnan, S. (2001). 'The dynamics of the adoption of product and process innovations in organizations'. *Journal of Management Studies,* **38**, 45-65.

Dasgupta, P., and David, P. (1994). 'Towards a new economics of science'. *Research Policy,* **23**, 487-522.

Dierickx, I., and Cool, K. (1989). 'Asset stock accumulation and sustainability of competitive advantage'. *Management Science,* **35**, 1504-11.

Dodgson, M., Gann, D., and Salter, A. (2005). *Think, Play, Do: Markets, Technology and Organization*. London: Oxford University Press.

DTI. (2005). *UK Innovation Survey*. Retrieved June, 2006, from http://www.dti.gov.uk/files/file9673.pdf

Ennen, E., and Richter, A. (2010). 'The Whole Is More Than the Sum of Its Parts: Or Is It? A Review of the Empirical Literature on Complementarities in Organization'. *Journal of Management,* **36**, 207-33.

Fey, C. F., and Birkinshaw, J. (2005). 'External Sources of Knowledge, Governance Mode, and R&D Performance'. *Journal of Management,* **31**, 597-621.

Fleming, L., and Sorenson, O. (2004). 'Science as a map in technological search'. *Strategic Management Journal,* **25**, 909-28.

Foss, N., Laursen, K., and Pedersen, T. (2011). 'Linking customer interaction and innovation: The mediating role of new organizational practices'. *Organization Science,* **forthcoming**.

Freeman, C., and Soete, L. L. G. (1997). *The Economics of Industrial Innovation*. London: Pinter.

Grimpe, C., and Sofka, W. (2009). 'Search Patterns and Absorptive Capacity: Low- and High-Technology Sectors in European Countries'. *Research Policy,* **38**, 495–506.

Hagedoorn, J., and Duysters, G. (2002). 'External sources of innovative capabilities: The preference for strategic alliances or mergers and acquisitions'. *Journal of Management Studies,* **39**, 167-88.

Hall, B. H., Lotti, F., and Mairesse, J. (2009). 'Innovation and productivity in SMEs: empirical evidence for Italy '. *Small Business Economics,* **33**, 13-33.

Hargadon, A., and Sutton, R. (1997). 'Technology brokering and innovation in a product development firm'. *Administrative Science Quarterly,* **42**, 716-49.

Hatch, N., and Mowery, D. C. (1998). 'Process Innovation and Learning by Doing in Semiconductor Manufacturing'. *Management Science,* **44**, 1461-77.

Hayek, F. A. v. (1948). 'The Use of Knowledge in Society'. In *Individualism and Economic Order*. Chicago: University of Chicago Press, 77-91.

He, Z., and Wong, P. (2004). 'Exploration vs. Exploitation: An Empirical Test of the Ambidexterity Hypothesis'. *Organization Science,* **15**, 481-94.

Helfat, C. (1994). 'Evolutionary Trajectories in Petroleum Firm R&D'. *Management Science,* **40**, 1720-47.

Henderson, R., Jaffe, A., and Trajtenberg, M. (1998). 'Universities as a source of commercial technology: A detailed analysis of university patenting'. *Review of Economic and Statistics,* **80**, 119-27.

Ichniowski, C., Shaw, K., and Prennushi, G. (1997). 'The Effects of Human Resource Management Practices on Productivity: A Study of Steel Finishing Lines'. *American Economic Review,* **87**, 291-313.

Jaffe, A. (1989). 'Real Effects of Academic Research'. *American Economic Review,* **79**, 957-70.

Jansen, J. J. P., George, G., Van den Bosch, F. A. J., and Volberda, H. W. (2008). 'Senior Team Attributes and Organizational Ambidexterity: The Moderating Role of Transformational Leadership'. *Journal of Management Studies,* **45**, 982-1007.

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

Katila, R., and Ahuja, G. (2002). 'Something old, something new: A longitudinal study of search behaviour and new product introduction'. *Academy of Management Journal,* **45**, 1183-94.

Katz, R., and Allen, T. (1982). 'Investigating the Not Invented Here (NIH) syndrome: A look at the performance, tenure, and communication patterns of 50 R&D projects'. *R&D Management,* **12**, 7-19.

Klevorick, A. K., Levin, R. C., Nelson, R. R., and Winter, S. G. (1995). 'On the sources and significance of interindustry differences in technological opportunities'. *Research Policy,* **24**, 185-205.

Kogut, B., and Zander, U. (1992). 'Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology'. *Organization Science* **3**, 383-97.

Laursen, K., and Salter, A. (2004). 'Searching low and high: what types of firms use universities as a source of innovation'. *Research Policy,* **33**, 1201-15.

Laursen, K., and Salter, A. J. (2006). 'Open for Innovation: The role of openness in explaining innovative performance among UK manufacturing firms'. *Strategic Management Journal*, **27**, 131-50.

Leiponen, A., and Helfat, C. E. (2010a). 'Innovation Opportunities, Knowledge Sources, and the Benefits of Breadth'. *Strategic Management Journal*, **31**, 224-36.

Leiponen, A., and Helfat, C. E. (2010b). 'Location, Decentralization, and Knowledge Sources for Innovation'. *Organization Science*, **forthcoming**.

Levinthal, D. A., and March, J. G. (1993). 'The myopia of learning'. *Strategic Management Journal*, **14**, 95-112.

Love, J. H., Roper, S., and Du, J. (2009). 'Innovation, ownership and profitability'. *International Journal of Industrial Organization*, **27**, 424-34.

Lundvall, B.-Å. (Ed.). (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publishers.

Mairesse, J., and Mohnen, P. (2002). 'Accounting for Innovation and Measuring Innovativeness: An Illustrative Framework and an Application'. *American Economic Review*, **92**, 226-31.

Mansfield, E. (1991). 'Academic Research and Industrial Innovation'. *Research Policy*, **20**, 1-12.

March, J. G. (1991). 'Exploration and Exploitation in Organization Learning'. *Organization Science*, **2**, 71-87.

Markman, G. D., Siegel, D. S., and Wright, M. (2008). 'Research and Technology Commercialization'. *Journal of Management Studies*, **45**, 1401 - 23.

Martinez-Ros, E. (2000). 'Explaining the decisions to carry out product and process innovations: the Spanish case'. *Journal of High Technology Management Research*, **10**, 223-42.

McEvily, S. K., and Chakravarthy, B. (2002). 'The Persistence of Knowledge-based Advantage: An Empirical Test for Product Performance and Technological Knowledge'. *Strategic Management Journal*, **23**, 285-305.

Menon, T., and Pfeffer, J. (2003). 'Valuing Internal vs. External Knowledge: Explaining the Preference for Outsiders'. *Management Science*, **49**, 497-513.

Meyer-Krahmer, F., and Schmoch, U. (1998). 'Science-based technologies: university-industry interactions in four fields'. *Research Policy*, **27**, 835-51.

Nelson, R. R. (Ed.). (1993). *National Innovation Systems: A Comparative Analysis*. New York: Oxford University Press.

Nelson, R. R., and Rosenberg, N. (1994). 'American universities and technical advance'. *Research Policy*, **23**, 323-48.

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

Nooteboom, B. (2000). 'Learning by Interaction: Absorptive Capacity, Cognitive Distance and Governance'. *Journal of Management and Governance,* **4**, 69-92.

Ocasio, W. (1997). 'Towards an attention-based view of the firm'. *Strategic Management Journal,* **18**, 187-206.

Pavitt, K. L. R. (1984). 'Sectoral patterns of technical change: towards a taxonomy and a theory'. *Research Policy,* **13**, 343-73.

Pisano, G. (1997). *The Development Factory: Unlocking the Potential of Process Innovation*. Boston: Harvard Business School Press.

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., and Podsakoff, N. P. (2003). 'Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies'. *Journal of Applied Psychology,* **88**, 879–903.

Powell, W. W., Koput, K. W., and Smith-Doerr, L. (1996). 'Interorganizational collaboration and the local of innovation: Networks of learning in biotechnology'. *Administrative Science Quarterly,* **41**, 116-45.

Reichstein, T., and Salter, A. (2006). 'Investigating the sources of process innovation among UK manufacturing firms'. *Industrial and Corporate Change,* **15**, 653–82.

Rigby, D., and Cook, C. (2002). 'Open-Market Innovation '. *Harvard Business Review,* **October**, 80-89.

Robson, S., and Ortmans, L. (2006). 'First findings from the UK Innovation Survey, 2005'. *Economic Trends,* **628**, 58-64.

Rosenberg, N. (1976). *Perspectives on Technology*. Cambridge: Cambridge University Press.

Rosenberg, N. (1982). *Inside the Black Box: Technology and Economics*. Cambridge, UK: Cambridge University Press.

Rosenberg, N. (1990). 'Why Do Firms Do Basic Research (with Their Own Money)?'. *Research Policy,* **19**, 165-74.

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

Rothaermel, F. T., and Alexandre, M. T. (2009). 'Ambidexterity in technology sourcing: The moderating role of absorptive capacity'. *Organization Science,* **20**, 759-80.

Sakkab, N. Y. (2002). 'Connect and develop complements research and develop at P&G'. *Research-Technology Management,* **45**, 38-45.

Sammarra, A., and Biggiero, L. (2008). 'Heterogeneity and Specificity of Inter-Firm Knowledge Flows in Innovation Networks'. *Journal of Management Studies,* **45**, 800 - 29.

Schumpeter, J. A. (1912/34). *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle*. London: Oxford University Press.

Smith, K. (2005). 'Measuring Innovation'. In Fagerberg, J., Mowery, D. C. and Nelson, R. R. (Eds.), *The Oxford Handbook of Innovation*. Oxford: Oxford University Press, 148-79.

Sobrero, M., and Roberts, E. B. (2001). 'The Trade-off Between Efficiency and Learning in Interorganizational Relationships for Product Development'. *Management Science,* **47**, 493-51.

Spencer, J. W. (2001). 'How Relevant Is University-Based Scientific Research To Private High-Technology Firms? A United States-Japan Comparison'. *Academy of Management Journal,* **44**, 432-40.

Spencer, J. W. (2003). 'Firms' Knowledge-Sharing Strategies in the Global Innovation System: Emprical Evidence from the Flat Panel Display Industry'. *Strategic Management Journal,* **24**, 217-33.

Stuart, T., and Podolny, J. (1996). 'Local search and the evolution of technological capabilities'. *Strategic Management Joural,* **17**, 21-38.

Szulanski, G. (1996). 'Exploiting internal stickiness: impediments to the transfer of best practice'. *Strategic Management Journal,* **17**, 27-43.

Teece, D. J., Pisano, G., and Shuen, A. (1997). 'Dynamic capabilities and strategic management'. *Strategic Management Journal,* **18**, 509-33.

Thompson, P. (2006). 'Patent Citations and the Geography of Knowledge Spillovers: Evidence from Inventor- and Examiner-added Citations'. *Review of Economics and Statistics,* **88**, 383-88.

Tushman, M. L., and Anderson, P. (1986). 'Technological discontinuities and organizational environments'. *Administrative Science Quarterly,* **31**, 439-65.

Tushman, M. L., and O'Reilly, C. A. (1996). 'Ambidextrous organizations: Managing evolutionary and revolutionary change'. *California Management Review,* **38**, 8–30.

Urban, G. L., and von Hippel, E. (1988). 'Lead user analysis for development of new industrial products'. *Management Science,* **34**, 569-82.

Utterback, J. M. (1994). *Mastering the Dynamics of Innovation*. Boston: Harvard Business School Press.

von Hippel, E. (1988). *The Sources of Innovation*. New York: Oxford University Press.

von Hippel, E. (2001). 'User toolkits for innovation'. *Journal of Product Innovation Management,* **18**, 247-57.

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

Womack, J. P., Jones, D. T., and Roos, D. (1990). *The Machine that Changed the World: The Story of Lean Production*. New York: Rawson Associates.

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

Zott, C. (2003). 'Dynamic Capabilities and the Emergence of Intraindustry Differential Firm Performance: Insights From a Simulation Study'. *Strategic Management Journal*, **24**, 97-125.

Zucker, L., Darby, M., and Brewer, M. (1998). 'Intellectual Capital and the Birth of the U.S. Biotechnology Enterprises'. *American Economic Review*, **88**, 290-306.

Table 1 Search strategies

Search strategy	Number of firms
No sources	1976
Internal sources only	167
External sources only	
Suppliers only	197
Customers only	148
Competitors only	25
Universities only	13
Suppliers & Customers	205
Suppliers & Competitors	27
Suppliers & Universities	12
Customers & Competitors	123
Suppliers, Customers & Competitors	273
Suppliers, Customers & Universities	19
Suppliers, Customers, Competitors & Universities	34
Ambidextrous search strategies	
Internal & Suppliers	258
Internal & Customers	218
Internal & Competitors	23
Internal & Universities	18
Internal, Suppliers & Customers	613
Internal, Suppliers & Competitors	82
Internal, Suppliers & Universities	35
Internal, Customers & Competitors	278
Internal, Customers & Universities	23
Internal, Suppliers, Competitors & Universities	1273
Internal, Suppliers, Customers & Universities	103
Internal, Suppliers, Customers & Competitors	18
Internal, Customers, Competitors & Universities	37
All sources	570

Table 2 Descriptive statistics

Variable	Mean	Std. Dev.
Product Innovation	0.247	0.431
Process Innovation	0.153	0.360
Firm Size (log employees)	4.179	1.512
Firm Age	21.905	9.671
Corporate Venture	0.343	0.475
Domestic	0.664	0.472
Government Funding	0.092	0.289
R&D Investment	0.277	0.447
Innovation Cooperation	0.151	0.358
National Market Focus	0.322	0.467
European Market Focus	0.130	0.336
Beyond Europe Market Focus	0.221	0.415
Share of scientists & engineers	5.255	14.540
Internal sources only	0.025	0.155
Suppliers only	0.029	0.168
Customers only	0.022	0.146
Competitors only	0.004	0.061
Universities only	0.002	0.044
Suppliers & Customers	0.030	0.171
Suppliers & Competitors	0.004	0.063
Suppliers & Universities	0.002	0.042
Customers & Competitors	0.018	0.134
Suppliers, Customers & Competitors	0.040	0.197
Suppliers, Customers & Universities	0.003	0.053
Suppliers, Customers, Competitors & Universities	0.003	0.053
Internal & Suppliers	0.038	0.192
Internal & Customers	0.032	0.177
Internal & Competitors	0.003	0.058
Internal & Universities	0.003	0.052
Internal, Suppliers & Customers	0.091	0.287
Internal, Suppliers & Competitors	0.012	0.109
Internal, Suppliers & Universities	0.005	0.072
Internal, Customers & Competitors	0.041	0.198
Internal, Customers & Universities	0.003	0.058
Internal, Suppliers, Customers & Competitors	0.188	0.391
Internal, Suppliers, Customers & Universities	0.015	0.122
Internal, Suppliers, Competitors & Universities	0.003	0.052
Internal, Customers, Competitors & Universities	0.005	0.074
All sources	0.084	0.278

Table 2 Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	Product Innovation	1																				
2	Process Innovation	0.46	1																			
3	Firm Size	0.06	0.09	1																		
4	Firm Age	-0.02	0.00	0.16	1																	
5	Corporate Venture	0.08	0.06	0.36	0.03	1																
6	Domestic	-0.07	-0.04	-0.28	-0.07	-0.29	1															
7	Government Funding	0.20	0.15	0.00	-0.03	0.03	-0.03	1														
8	R&D Investment	0.29	0.21	0.11	-0.02	0.13	-0.07	0.24	1													
9	Innovation Cooperation	0.18	0.16	0.09	-0.01	0.1	-0.06	0.23	0.29	1												
10	National Market Focus	-0.07	-0.02	0.06	-0.04	0.00	-0.05	-0.07	-0.07	-0.06	1											
11	European Market Focus	0.06	0.04	0.02	0.02	0.05	-0.02	0.02	0.07	0.02	-0.26	1										
12	Beyond Europe Market Focus	0.22	0.16	0.13	0.07	0.2	-0.08	0.18	0.28	0.18	-0.36	-0.2	1									
13	Share of scientists & engineers	0.15	0.10	0.00	-0.06	0.08	-0.04	0.2	0.21	0.16	-0.05	0.02	0.2	1								
14	Internal sources only	-0.01	-0.02	0.00	0.00	0.03	0.00	-0.01	0.00	-0.02	0.00	0.00	0.01	-0.02	1							
15	Suppliers only	-0.04	0.00	-0.06	-0.01	-0.04	0.02	-0.01	-0.05	-0.03	0.02	-0.02	-0.04	-0.02	-0.02	1						
16	Customers only	-0.03	-0.03	-0.03	-0.01	-0.04	0.02	-0.03	-0.05	-0.02	-0.02	0.00	-0.01	-0.02	-0.02	-0.03	1					
17	Competitors only	-0.02	-0.01	0.00	-0.01	0.00	0.00	-0.01	-0.03	-0.02	0.00	-0.01	-0.01	-0.01	0.00	-0.01	0.00	1				
18	Universities only	-0.02	-0.01	0.00	-0.01	-0.01	0.01	0.02	-0.01	0.01	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	1			
19	Suppliers & Customers	-0.04	-0.03	-0.06	0.01	-0.05	0.02	-0.02	-0.06	0.00	0.00	0.00	-0.02	-0.02	-0.02	-0.03	-0.02	-0.01	0.00	1		
20	Suppliers & Competitors	0.00	0.01	-0.02	0.00	-0.01	0.00	-0.01	-0.02	-0.01	0.02	0.00	-0.02	-0.01	-0.01	-0.01	0.00	0.00	0.00	-0.01	1	
21	Suppliers & Universities	0.01	0.02	-0.01	-0.01	0.00	0.00	0.01	0.01	0.01	0.00	-0.01	0.00	0.02	0	-0.01	0.00	0.00	0.00	0.00	0.00	1
22	Customers & Competitors	-0.02	0.00	0.00	0.00	-0.01	0.00	-0.01	-0.06	-0.03	0.00	-0.02	0.00	-0.03	-0.02	-0.02	-0.02	0.00	0.00	-0.02	0.00	0.00

All correlations >= |0.00| are significant at the 5% level.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
23	Suppliers, Customers & Competitors	-0.02	0	-0.03	-0.01	-0.03	0.03	-0.02	-0.06	-0.02	0.00	0.00	-0.02	-0.02	-0.03	-0.04	-0.03	-0.01	0.00
24	Suppliers, Customers & Universities	-0.01	-0.01	-0.02	0.00	-0.01	0.00	-0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.00	-0.01	0.00	0.00	0.00
25	Suppliers, Customers, Competitors & Universities	0.01	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	-0.01	-0.01	-0.01	0.00	0.00
26	Internal & Suppliers	0.02	0.04	0.00	0.00	0.02	-0.01	0.01	0.05	0.00	0.00	0.02	0.02	0.01	-0.03	-0.03	-0.02	-0.01	0.00
27	Internal & Customers	0.02	0.02	0.00	0.01	0.01	0.00	0.00	0.07	0.00	0.00	0.03	0.02	0.05	-0.02	-0.03	-0.02	-0.01	0.00
28	Internal & Competitors	0.01	-0.01	0.00	0.00	0.01	-0.01	0.00	0.02	0.00	0.00	-0.01	0.01	0.00	0.00	-0.01	0.00	0.00	0.00
29	Internal & Universities	-0.01	0.00	0.00	-0.01	0.01	0.00	0.03	0.02	0.01	0.01	0.01	0.00	0.03	0.00	-0.01	0.00	0.00	0.00
30	Internal, Suppliers & Customers	0.06	0.04	0.01	-0.02	0.01	-0.04	0.03	0.14	0.06	0.00	0.05	0.04	0.01	-0.05	-0.05	-0.04	-0.01	-0.01
31	Internal, Suppliers & Competitors	0.00	0.00	0.01	0.00	0.00	-0.01	-0.02	0.02	0.01	0.00	0.00	-0.01	-0.01	-0.01	-0.02	-0.01	0.00	0.00
32	Internal, Suppliers & Universities	0.03	0.00	0.01	0.03	0.01	0.00	0.08	0.07	0.07	-0.02	0.01	0.04	0.05	-0.01	-0.01	-0.01	0.00	0.00
33	Internal, Customers & Competitors	0.05	0.03	0.04	0.00	0.04	0.00	0.02	0.10	0.02	0.00	0.02	0.03	0.03	-0.03	-0.04	-0.03	-0.01	0.00
34	Internal, Customers & Universities	0.05	0.03	0.01	0.00	0.01	-0.01	0.07	0.04	0.05	-0.01	0.00	0.04	0.09	0.00	-0.01	0.00	0.00	0.00
35	Internal, Suppliers, Customers & Competitors	0.12	0.09	0.11	-0.01	0.10	-0.05	0.05	0.18	0.10	0.00	0.04	0.07	0.01	-0.07	-0.08	-0.07	-0.02	-0.02
36	Internal, Suppliers, Customers & Universities	0.06	0.07	0.01	-0.01	0.01	0.00	0.10	0.09	0.09	-0.01	0.00	0.03	0.07	-0.01	-0.02	-0.01	0.00	0.00
37	Internal, Suppliers, Competitors & Universities	0.04	0.03	0.01	0.00	0.02	0.00	0.08	0.05	0.05	-0.01	-0.01	0.04	0.05	0.00	-0.01	0.00	0.00	0.00
38	Internal, Customers, Competitors & Universities	0.05	0.00	0.06	0.01	0.03	0.00	0.01	0.06	0.06	-0.01	0.00	0.04	0.02	-0.01	-0.01	-0.01	0.00	0.00
39	All sources	0.07	0.06	0.08	-0.01	0.05	-0.04	0.12	0.11	0.13	-0.02	-0.02	0.09	0.09	-0.04	-0.05	-0.04	-0.01	-0.01

All correlations >= |0.00| are significant at the 5% level.

		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
23	Suppliers, Customers & Competitors	-0.03	-0.01	0.00	-0.03	1															
24	Suppliers, Customers & Universities	0.00	0.00	0.00	-0.01	-0.01	1														
25	Suppliers, Customers, Competitors & Universities	-0.01	0.00	0.00	-0.01	-0.01	0.00	1													
26	Internal & Suppliers	-0.03	-0.01	0.00	-0.03	-0.04	-0.01	-0.01	1												
27	Internal & Customers	-0.03	-0.01	0.00	-0.02	-0.03	0.00	-0.01	-0.03	1											
28	Internal & Competitors	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01	-0.01	1										
29	Internal & Universities	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01	0.00	0.00	1									
30	Internal, Suppliers & Customers	-0.05	-0.02	-0.01	-0.04	-0.06	-0.01	-0.02	-0.06	-0.05	-0.01	-0.02	1								
31	Internal, Suppliers & Competitors	-0.01	0.00	0.00	-0.02	-0.02	0.00	0.00	-0.02	-0.02	0.00	-0.01	-0.03	1							
32	Internal, Suppliers & Universities	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.02	0	1						
33	Internal, Customers & Competitors	-0.03	-0.01	0.00	-0.03	-0.04	-0.01	-0.01	-0.04	-0.03	-0.01	-0.01	-0.06	-0.02	-0.01	1					
34	Internal, Customers & Universities	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01	0.00	0.00	-0.01	1				
35	Internal, Suppliers, Customers & Competitors	-0.08	-0.03	-0.02	-0.07	-0.09	-0.02	-0.03	-0.09	-0.08	-0.02	-0.02	-0.15	-0.05	-0.03	-0.09	-0.02	1			
36	Internal, Suppliers, Customers & Universities	-0.02	0.00	0.00	-0.02	-0.02	0.00	0.00	-0.02	-0.02	0.00	-0.01	-0.03	-0.01	0.00	-0.02	0.00	-0.05	1		
37	Internal, Suppliers, Competitors & Universities	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	-0.02	-0.01	1	
38	Internal, Customers, Competitors & Universities	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.02	0.00	0.00	-0.01	0.00	-0.03	-0.01	0.00	1
39	All sources	-0.05	-0.01	-0.01	-0.04	-0.06	-0.01	-0.02	-0.06	-0.05	-0.01	-0.02	-0.09	-0.03	-0.02	-0.06	-0.01	-0.14	-0.04	-0.01	-0.02

All correlations >= |0.00| are significant at the 5% level.

Table 4 Results from the bivariate probit estimations

	Baseline Model				Full Model			
	Product Innovation		Process Innovation		Product Innovation		Process Innovation	
Firm Size (log employees)	0.022	(0.013)	0.078***	(0.015)	0.008	(0.014)	0.071***	(0.015)
Firm Age	-0.004*	(0.002)	-0.003	(0.002)	-0.003	(0.002)	-0.002	(0.002)
Corporate Venture	-0.012	(0.041)	-0.030	(0.045)	-0.032	(0.041)	-0.044	(0.045)
Domestic	-0.097**	(0.039)	-0.032	(0.043)	-0.095**	(0.039)	-0.025	(0.043)
Government Funding	0.362***	(0.059)	0.267***	(0.059)	0.315***	(0.059)	0.216***	(0.062)
R&D Investment	0.508***	(0.041)	0.373***	(0.045)	0.385***	(0.043)	0.254***	(0.047)
Innovation Cooperation	0.248***	(0.049)	0.294***	(0.052)	0.188***	(0.049)	0.242***	(0.052)
National Market Focus	0.076	(0.048)	0.174***	(0.054)	0.057	(0.048)	0.150***	(0.055)
European Market Focus	0.277***	(0.061)	0.238***	(0.068)	0.239***	(0.061)	0.200***	(0.069)
Beyond Europe Market Focus	0.386***	(0.056)	0.283***	(0.063)	0.353***	(0.056)	0.259***	(0.064)
Share of scientists & engineers	0.005***	(0.001)	0.003***	(0.001)	0.004***	(0.001)	0.003**	(0.001)
Internal sources only					0.173	(0.116)	0.167	(0.142)
Suppliers only					0.064	(0.119)	0.463***	(0.119)
Customers only					0.119	(0.133)	0.151	(0.164)
Competitors only					0.051	(0.355)	-0.127	(0.453)
Universities only					-0.666	(0.423)	-7.024***	(0.133)
Suppliers & Customers					0.043	(0.117)	0.177	(0.137)
Suppliers & Competitors					0.399	(0.275)	0.799***	(0.276)
Suppliers & Universities					0.549	(0.402)	1.018***	(0.375)
Customers & Competitors					0.241*	(0.136)	0.427***	(0.151)
Suppliers, Customers & Competitors					0.264***	(0.094)	0.440***	(0.107)
Suppliers, Customers & Universities					-0.010	(0.373)	-0.273	(0.462)
Suppliers, Customers, Competitors & Universities					0.481*	(0.251)	0.797***	(0.239)
Internal & Suppliers					0.302***	(0.097)	0.575***	(0.104)
Internal & Customers					0.307***	(0.102)	0.469***	(0.112)
Internal & Competitors					0.474*	(0.273)	0.258	(0.388)
Internal & Universities					-0.327	(0.401)	0.232	(0.330)
Internal, Suppliers & Customers					0.378***	(0.070)	0.442***	(0.080)
Internal, Suppliers & Competitors					0.335**	(0.162)	0.527***	(0.176)
Internal, Suppliers & Universities					0.205	(0.242)	-0.043	(0.263)
Internal, Customers & Competitors					0.424***	(0.093)	0.489***	(0.102)
Internal, Customers & Universities					0.939***	(0.276)	0.724**	(0.284)
Internal, Suppliers, Customers & Competitors					0.455***	(0.058)	0.511***	(0.067)
Internal, Suppliers, Customers & Universities					0.515***	(0.138)	0.768***	(0.143)
Internal, Suppliers, Competitors & Universities					0.552*	(0.298)	0.645*	(0.333)
Internal, Customers, Competitors & Universities					0.724***	(0.234)	0.037	(0.257)
All sources					0.394***	(0.073)	0.468***	(0.082)
Constant	-0.915***	(0.109)	-1.454***	(0.119)	-1.059***	(0.114)	-1.727***	(0.127)
Observations	6768		6768		6768		6768	
$\hat{\rho}$	0.782***				0.773***			
Log-pseudolikelihood	-5512		-5512		-5425		-5425	
Wald chi2	1099***		1099***		24147***		24147***	

All models include sector dummies. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Reference category for the search strategy dummies is the absence of a search strategy.

Table 5 Search strategy comparison matrix for product innovation: *t*-tests on the coefficients estimates from the bivariate probit model

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1 Internal sources only	0.17	-				*																					
2 Suppliers only	0.06		-			*																					
3 Customers only	0.12			-		*																					
4 Competitors only	0.05				-																						
5 Universities only	-0.67					-																					
6 Suppliers & Customers	0.04						-																				
7 Suppliers & Competitors	0.40					**		-																			
8 Suppliers & Universities	0.55					**			-																		
9 Customers & Competitors	0.24					**				-																	
10 Suppliers, Customers & Competitors	0.26					**					-																
11 Suppliers, Customers & Universities	-0.01											-															
12 Suppliers, Customers, Competitors & Universities	0.48					**							-				*										
13 Internal & Suppliers	0.30		*			**	*							-													
14 Internal & Customers	0.31		*			**	*								-												
15 Internal & Competitors	0.47					**										-	*										
16 Internal & Universities	-0.33																-										
17 Internal, Suppliers & Customers	0.38	*	**	*		**	***										*	-									
18 Internal, Suppliers & Competitors	0.34					**													-								
19 Internal, Suppliers & Universities	0.20					*														-							
20 Internal, Customers & Competitors	0.42	*	***	**		**	***										*				-						
21 Internal, Customers & Universities	0.94	***	***	***	**	***	***			**	**	**		**	**		***	**	*	**	*	-	*				**
22 Internal, Suppliers, Customers & Competitors	0.45	**	***	**		***	***				**						**						-				
23 Internal, Suppliers, Customers & Universities	0.51	**	***	**		***	***										**							-			
24 Internal, Suppliers, Competitors & Universities	0.55					**											*								-		
25 Internal, Customers, Competitors & Universities	0.72	**	***	**		***	***			*	*	*		*	*		**									-	
26 All sources	0.39	*	***	**		**	***										*										-

*** $p<0.01$, ** $p<0.05$, * $p<0.1$; coefficient estimates from the bivariate model reported in the second column. Only shown results of the *t*-tests when the coefficient in the row is greater than the coefficient in the column.

Table 6 Search strategy comparison matrix for process innovation: *t*-tests on the coefficients estimates from the bivariate probit model

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	Internal sources only	0.17	-				***																					
2	Suppliers only	0.46	*	-			***	*													*							
3	Customers only	0.15			-		***																					
4	Competitors only	-0.13				-	***																					
5	Universities only	-7.02					-																					
6	Suppliers & Customers	0.18					***	-																				
7	Suppliers & Competitors	0.80	**		**	*	***	**	-				**								**						**	
8	Suppliers & Universities	1.02	**		**	**	***	**		-			**								**						**	
9	Customers & Competitors	0.43					***				-																	
10	Suppliers, Customers & Competitors	0.44	*				***	*				-									*							
11	Suppliers, Customers & Universities	-0.27					***						-															
12	Suppliers, Customers, Competitors & Universities	0.80	**		**	*	***	**					**	-							**						**	
13	Internal & Suppliers	0.58	**		**		***	**					*		-						**						**	
14	Internal & Customers	0.47	*		*		***	*								-					*							
15	Internal & Competitors	0.26					***										-											
16	Internal & Universities	0.23					***											-										
17	Internal, Suppliers & Customers	0.44	*		*		***	*											-		*							
18	Internal, Suppliers & Competitors	0.53	*				***	*												-	*							
19	Internal, Suppliers & Universities	-0.04					***														-							
20	Internal, Customers & Competitors	0.49	**		*		***	**													**	-					*	
21	Internal, Customers & Universities	0.72	*		*		***	*					*								**		-				*	
22	Internal, Suppliers, Customers & Competitors	0.51	**		**		***	**					*								**			-			*	
23	Internal, Suppliers, Customers & Universities	0.77	***	*	***	*	***	***			*	**	**			*			**		***	*		*	-		***	**
24	Internal, Suppliers, Competitors & Universities	0.64					***														*					-		
25	Internal, Customers, Competitors & Universities	0.04					***																				-	
26	All sources	0.47	**		*		***	**													*						*	-

*** $p<0.01$, ** $p<0.05$, * $p<0.1$; coefficient estimates from the bivariate model reported in the second column. Only shown results of the *t*-tests when the coefficient in the row is greater than the coefficient in the column.

Table A1 Results from the probit estimations

	Product Innovation		Process Innovation		Product Innovation		Process Innovation	
Firm Size (log employees)	0.022*	(0.013)	0.080***	(0.015)	0.008	(0.014)	0.071***	(0.015)
Firm Age	-0.004*	(0.002)	-0.003	(0.002)	-0.003	(0.002)	-0.002	(0.002)
Corporate Venture	-0.012	(0.041)	-0.037	(0.045)	-0.032	(0.041)	-0.052	(0.045)
Domestic	-0.098**	(0.039)	-0.039	(0.043)	-0.095**	(0.039)	-0.033	(0.044)
Government Funding	0.366***	(0.059)	0.269***	(0.062)	0.318***	(0.059)	0.214***	(0.062)
R&D Investment	0.507***	(0.041)	0.361***	(0.045)	0.383***	(0.043)	0.239***	(0.047)
Innovation Cooperation	0.249***	(0.049)	0.305***	(0.052)	0.187***	(0.049)	0.250***	(0.052)
National Market Focus	0.074	(0.048)	0.168***	(0.055)	0.056	(0.048)	0.150***	(0.056)
European Market Focus	0.274***	(0.061)	0.232***	(0.069)	0.239***	(0.061)	0.195***	(0.070)
Beyond Europe Market Focus	0.385***	(0.056)	0.281***	(0.064)	0.352***	(0.056)	0.262***	(0.064)
Share of scientists & engineers	0.005***	(0.001)	0.003**	(0.001)	0.004***	(0.001)	0.003**	(0.001)
Internal sources only					0.172	(0.117)	0.172	(0.143)
Suppliers only					0.064	(0.119)	0.444***	(0.123)
Customers only					0.098	(0.137)	0.111	(0.169)
Competitors only					0.069	(0.348)	-0.087	(0.486)
Universities only					-0.668	(0.423)		
Suppliers & Customers					0.036	(0.118)	0.172	(0.140)
Suppliers & Competitors					0.375	(0.283)	0.793***	(0.276)
Suppliers & Universities					0.554	(0.375)	1.045***	(0.374)
Customers & Competitors					0.246*	(0.136)	0.417***	(0.155)
Suppliers, Customers & Competitors					0.267***	(0.094)	0.447***	(0.108)
Suppliers, Customers & Universities					0	(0.365)	-0.196	(0.475)
Suppliers, Customers, Competitors & Universities					0.472*	(0.243)	0.797***	(0.236)
Internal & Suppliers					0.304***	(0.096)	0.591***	(0.104)
Internal & Customers					0.310***	(0.102)	0.471***	(0.113)
Internal & Competitors					0.473*	(0.285)	0.198	(0.405)
Internal & Universities					-0.276	(0.358)	0.257	(0.336)
Internal, Suppliers & Customers					0.379***	(0.070)	0.441***	(0.081)
Internal, Suppliers & Competitors					0.323*	(0.168)	0.509***	(0.180)
Internal, Suppliers & Universities					0.198	(0.237)	-0.017	(0.269)
Internal, Customers & Competitors					0.430***	(0.093)	0.500***	(0.103)
Internal, Customers & Universities					0.932***	(0.274)	0.751***	(0.280)
Internal, Suppliers, Customers & Competitors					0.458***	(0.058)	0.521***	(0.068)
Internal, Suppliers, Customers & Universities					0.524***	(0.136)	0.789***	(0.142)
Internal, Suppliers, Competitors & Universities					0.567*	(0.299)	0.678**	(0.333)
Internal, Customers, Competitors & Universities					0.707***	(0.231)	0.049	(0.266)
All sources					0.396***	(0.073)	0.480***	(0.083)
Constant	-0.921***	(0.109)	-1.458***	(0.120)	-1.068***	(0.114)	-1.736***	(0.129)
Observations	6768		6755		6768		6755	
log pseudolikelihood	-3332		-2584		-3283		-2529	
Wald chi2	850.4		592		930.3		636.2	
p-value	0.119		0.107		0.132		0.126	

All models include sector dummies. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.