Technology Analysis & Strategic Management
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ctas20

Origins of knowledge and innovation in R&D alliances: a contingency approach

Antonio Capaldo[a] & Antonio Messeni Petruzzelli[b]
[a] S.E.GEST.A. Department of Management, Catholic University of the Sacred Heart, 1, Largo Francesco Vito, 00168 Rome, Italy
[b] Department of Mechanics, Mathematics, and Management, Politecnico di Bari, 182, Viale Japigia, 70126 Bari, Italy
Published online: 12 Feb 2015.

To cite this article: Antonio Capaldo & Antonio Messeni Petruzzelli (2015) Origins of knowledge and innovation in R&D alliances: a contingency approach, Technology Analysis & Strategic Management, 27:4, 461-483, DOI: 10.1080/09537325.2015.1011612

To link to this article: http://dx.doi.org/10.1080/09537325.2015.1011612

Technology Analysis & Strategic Management, 2015
Vol. 27, No. 4, 461–483, http://dx.doi.org/10.1080/09537325.2015.1011612

Origins of knowledge and innovation in R&D alliances: a contingency approach

Antonio Capaldo[a*] and Antonio Messeni Petruzzelli[b]

[a]*S.E.GEST.A. Department of Management, Catholic University of the Sacred Heart, 1, Largo Francesco Vito, 00168 Rome, Italy;* [b]*Department of Mechanics, Mathematics, and Management, Politecnico di Bari, 182, Viale Japigia, 70126 Bari, Italy*

Innovative performance is influenced both by the origins of the existing knowledge that is combined to generate innovation and by how economic actors search for new knowledge. Drawing on a sample of inter-firm dyadic R&D alliances, we found that whereas the integration of geographically distant knowledge and of organisationally proximate knowledge in R&D alliances are negatively related to the alliance innovative performance, search span positively moderates both relationships. We conclude that, in order to make the most of broad-span searching, firms participating in R&D alliances should integrate geographically distant but organisationally proximate knowledge. By doing so, firms take advantage of the diversity and novelty that characterises geographically distant knowledge, while preserving considerable levels of relative absorptive capacity that are needed for them to understand, internalise, and effectively use partners' knowledge from different domains.

Keywords: Interorganisational knowledge-intensive collaboration; innovation performance; search span; joint patents

1. Introduction

Innovation is a fundamental source of competitive advantage. A large literature has struggled to understand the drivers of innovation and how innovation processes should be managed in order to increase innovative performance (Teece 1986; Brown and Eisenhardt 1995; Crossan and Apaydin 2010). Evolutionary theorists and organisational scholars have taught us that innovation, be it radical or incremental, is a search process which leads to the creation of new knowledge (Nelson and Winter 1982; March 1991). The new knowledge, in turn, typically results from novel combinations of existing pieces of knowledge having different origins (Schumpeter 1934; Kogut and Zander 1992). Based on this stylised picture of the innovation process, we argue that, in order to deepen our understanding of the determinants of innovative performance, we should concentrate simultaneously on the origins of the existing knowledge that is combined to generate innovation and on how economic actors search for new knowledge. In the present study, we take a step towards developing this framework and testing it empirically.

*Corresponding author. Email: antonio.capaldo@unicatt.it

Although a significant stream of research has pointed to the innovation performance implications of combining knowledge resources from different origins, studies to date have reached mixed conclusions. Focusing on the geographic origin of knowledge, Phene, Fladmoe-Lindquist, and Marsh (2006) and Sidhu, Commandeur, and Volberda (2007) suggested that combining knowledge from geographically distant sources has a higher potential for variety and novelty, and hence for innovation. However, Gomes-Casseres, Hagedoorn, and Jaffe (2006) found that geographic proximity is positively related to knowledge flows between firms participating in R&D alliances. Looking at the organisational origin of knowledge, Rosenkopf and Nerkar (2001) found that the use of knowledge from other subunits of a same group has a substantially lower impact on innovation than the use of knowledge from outside firms. Nevertheless, in a subsequent study, Miller, Fern, and Cardinal (2007) have shown that drawing knowledge from different divisions or units belonging to the same group influences positively the impact of the resulting innovations, more so than drawing knowledge from organisations outside the group. Thus, the first objective of this study is to shed more light on the influence of the geographic and organisational origins of knowledge on innovative performance.

The origins of knowledge, however, are but one of the determinants of innovation. In fact, the characteristics of the processes by which firms search for new knowledge also exert significant influence on innovation and have the potential to shape, or even subvert, the impact of the origins of knowledge on innovation outcomes (Fleming and Sorenson 2001; Katila and Ahuja 2002). Extant research has explored several dimensions of search, for example, search depth, search scope, and search breadth (Katila and Ahuja 2002; Laursen and Salter 2006; Laursen 2012). We build on the observation that, as customer needs become increasingly multifaceted and the pace of competition intensifies, innovating firms increasingly resort to combining heterogeneous knowledge in order to generate complex innovations, spanning multiple different knowledge domains (Levinthal and March 1993). In order to capture this innovative behaviour, we refer to the notion of search span, that is, the extent to which firms search for new knowledge across different knowledge domains (Capaldo and Messeni Petruzzelli 2011). Thus, the second objective of this study is to ascertain whether and how search span moderates the influence of the geographic and organisational origins of knowledge on innovation performance.

We pursue the above two objectives at the interorganisational level of analysis, specifically in the context of R&D alliances. Previous studies have shown that firms and their innovative activities are embedded in inter-firm relationships and networks that affect innovative performance at the firm, dyad, and network levels (Powell, Koput, and Smith-Doerr 1996; Hoang and Rothaermel 2005). At least in part, this is due to the fact that organisations find it increasingly difficult to develop in-house all the complementary knowledge resources needed to innovate effectively (Powell, Koput, and Smith-Doerr 1996; Vanhaverbeke 2006). Therefore, firms largely resort to open innovation strategies in order to draw from various external sources a large variety of specialised knowledge inputs (Chesbrough 2003; Dahlander and Gann 2010). In particular, R&D alliances represent a widely adopted open innovation practice (e.g. Ahuja 2000; Schilling 2009) and are increasingly important units of analysis for understanding competitive advantage based on innovation (Sampson 2007; Capaldo and Messeni Petruzzelli 2014). As intended here, R&D alliances are dyadic knowledge-intensive inter-firm collaborative relationships aimed at developing innovation. Although firms participating in alliances often experience a mix of cooperation and competition (i.e. coopetitive relationships), which may hamper the open exchange of knowledge between them (e.g. Khanna, Gulati, and Nohria 1998; Ritala and Sainio 2013), knowledge-based interpretations of interorganisational collaboration suggest that R&D alliances allow partnered firms to jointly search for new knowledge by combining their own knowledge, or in other words, by integrating their respective knowledge bases (Powell, Koput, and Smith-Doerr 1996; Sakakibara 1997; Tzabbar, Aharonson, and Amburgey 2013). Along this way, R&D alliances constitute tremendous sources of knowledge and learning, considerably affecting innovation results and competitive advantage (Mowery, Oxley, and Silverman 1996; Stuart 2000; Jiang and Li 2009). Therefore, R&D alliances are an ideal context for the present study.

The primary purpose of this study is to expand our understanding of the determinants of the innovative performance of R&D alliances by focusing simultaneously on both (a) the geographic and organisational origins of the knowledge resources that partnered organisations contribute to, and integrate within, their alliances, and (b) the extent to which partnered organisations jointly search for new knowledge across different knowledge domains, that is, joint search span (simply search span hereinafter). In an attempt to overcome the difficulties that previous empirical research has experienced in dealing with alliance performance (Gulati 1998), we use joint patents (JPs) (i.e. patents jointly filed by, and therefore co-assigned to, two or more organisations) to identify our sample alliances and their innovation output and we measure alliance-level innovative performance by the number of citations each JP received from subsequent patents. Drawing on a sample of 1515 inter-firm dyadic R&D alliances established by 10 focal firms operating in the Electric and Electronic Equipment (EEE) industry, we find that although both the integration of geographically distant knowledge and the integration of organisationally proximate knowledge in R&D alliances negatively affect innovative performance at the alliance level, the alliance search span has a positive moderating effect on both relationships.

2. Theory and hypotheses

The geographic and organisational origins of the existing knowledge that is combined to generate new knowledge significantly affect innovation outcomes (McFadyen and Cannella 2005; Gomes-Casseres, Hagedoorn, and Jaffe 2006; Capaldo, Lavie, and Messeni Petruzzelli 2015). This is especially so in the case of R&D alliances, whose innovative potential is strictly dependent on the integration of knowledge across the boundaries of the participating organisations. However, the span of the allied firms' search may shape the influence of the origins of knowledge on innovation outcomes. In the following sections, we develop a set of testable hypotheses about the impacts of the geographic and organisational origins of knowledge on the innovative performance of R&D alliances and how such impacts are moderated by search span. Our conceptual model and the hypothesised relationships among the constructs of interest are summarised in Figure 1.

2.1. *Geographic origin of knowledge and the innovative performance of R&D alliances*

Previous studies have pointed out that knowledge is geographically bounded (Jaffe, Trajtenberg, and Henderson 1993) and suggested that a continuum exists which ranges from geographically proximate knowledge (i.e. knowledge provided by geographically proximate others) to geographically distant knowledge (i.e. knowledge provided by geographically distant others). The vast literature that has discussed the merits of geographic proximity has revealed that knowledge flows more readily to closer others, with positive effects on innovation (DeCarolis and Deeds 1999; Rosenkopf and Almeida 2003; Knoben and Oerlemans 2006). Accordingly, R&D alliances between geographically proximate partners have been shown to be major sources of knowledge and innovation (Gomes-Casseres, Hagedoorn, and Jaffe 2006).

Physical proximity reduces the risks of adverse partner selection and increases monitoring opportunities in the presence of misappropriation hazards or other sources of opportunism in

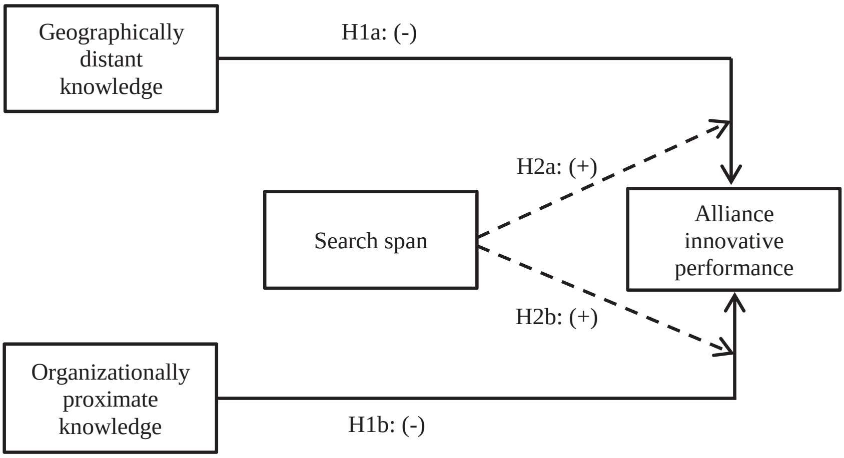

Figure 1. Conceptual model.

R&D collaboration (Reuer and Lahiri 2014). In addition, physical proximity facilitates repeated face-to-face interaction and communication (Ganesan, Malter, and Rindfleisch 2005; Weterings and Boschma 2009) and the development of idiosyncratic languages for transferring 'fine-grained information' between allied organisations (Uzzi 1997). Previous scholars have also shown that small geographic distance between partnered organisations stimulates the emergence of dense social networks across their boundaries, so increasing the opportunities for the effective combination of the partners' knowledge (Saxenian 1994). Indeed, a rich social fabric of interpersonal relationships encourages the development of trust-based relationships between spatially close organisations, with positive effects on their proclivity to participate in knowledge transfer activities (Uzzi 1997; Boschma 2005). All this fosters knowledge sharing between organisations, thereby enhancing innovation.

Geographic proximity also comes along with a common set of macro-level cultural habits and values, established practices, routines, and laws that help mutual understanding between allied organisations while also regulating and facilitating coordination and knowledge integration at the interorganisational level (Pouder and St. John 1996; Maskell and Malmberg 1999) Moreover, small geographic distance facilitates the development of local codes and common languages (Gertler 1995; Lawson and Lorenz 1999) which reduce transaction and communication costs (Maskell, Bathelt, and Malmberg 2006). Thus, geographically proximate partners typically find it easier to comprehend and effectively exploit each other's knowledge, thereby setting the stages for profitable knowledge-intensive interactions.

Building on the above, we expect that integrating geographically distant knowledge in R&D alliances negatively influences innovation for at least two sets of reasons. First, geographic distance between partners reduces monitoring opportunities in alliances, thus exacerbating the risks of opportunistic behaviours inherent in knowledge-intensive collaboration (Reuer and Lahiri 2014). Moreover, as geographic distance increases, individuals from allied firms find it more difficult to create and strengthen over time social relationships across the boundaries of their respective organisations (Boschma 2005). Thus, partnered organisations become less likely to develop trust-based relationships and more likely to behave opportunistically and even to engage in 'learning races' (Khanna, Gulati, and Nohria 1998) within the alliance, which in turn tends to negatively affect knowledge integration and innovation at the interorganisational level (Ganesan, Malter, and Rindfleisch 2005). Finally, geographic distance typically limits the partners' ability to interact repeatedly and therefore learn and develop over time the idiosyncratic languages needed for transferring knowledge between them, as well as to develop interorganisational routines for effective inter-firm knowledge integration (Romo and Schwartz 1995; Dyer and Nobeoka 2000). The integration of geographically distant knowledge may be particularly detrimental in the case of R&D alliances, where the knowledge to be shared is characterised by a considerable degree of tacitness (Coff 2003; Sampson 2007), which makes physical proximity between partners a primary condition for effective knowledge integration at the interorganisational level (Almeida and Kogut 1999. See also Zaheer and George 2004).

Second, distant geographic regions typically display different resource endowments, scientific capabilities, technological and regulatory environments, demand and supply conditions, manufacturing bases, industrial know-how, and infrastructures for transferring knowledge between public domain and industries (Cantwell 1989; Porter 1990). Such diversity may hinder mutual understanding and knowledge-intensive interactions between allied organisations from spatially distant contexts (Gertler 2001; Bathelt, Malmberg, and Maskell 2004), with negative effects on their ability to effectively integrate their respective knowledge, and so to jointly innovate. The arguments outlined above lead us to pose the following hypothesis:

> *Hypothesis 1a*. In R&D alliances, the integration of geographically distant knowledge is negatively related to the alliance innovative performance.

2.2. *Organisational origin of knowledge and the innovative performance of R&D alliances*

Organisational knowledge is, almost by definition, organisationally contextualised (Nelson and Winter 1982; Kogut and Zander 1992). Indeed, organisational knowledge emerges from firm-specific, path-dependent development processes and over time becomes embedded in idiosyncratic, firm-specific routines and capabilities which in turn affect its further evolution (Teece, Pisano, and Shuen 1997). Although this implies that the knowledge base of each single firm is unique and no two firms own the same knowledge, it also entails that the knowledge bases of different firms will be more or less organisationally proximate depending on how proximate the firms' internal organisational contexts are, or in other words, on the firms' organisational proximity.

Previous scholars have described organisational proximity as based on both a 'logic of belonging' and a 'logic of similarity' (Torre and Rallet 2005). The logic of belonging is strictly organisational, involving 'the rate of autonomy and the degree of control that can be exerted in organisational arrangements' (Boschma 2005, 65). Consequently, whereas organisationally proximate partners are tightly coupled and therefore have a low rate of autonomy and exert a high degree of control on each other (e.g. firms belonging to the same group), organisationally distant partners are loosely coupled, thus displaying considerable autonomy and exerting a low degree of control on each other (e.g. fully autonomous firms). The logic of similarity is eminently cognitive and is related to the notion of 'cognitive distance' (Nooteboom 2009), which refers to differences between organisations in terms of their shared fundamental categories of perception, interpretation, and evaluation inculcated by organisational culture. Having a similar/different organisational focus, organisationally proximate/distant firms are at low/high cognitive distance from each other.

Building on the notion of organisational proximity, we draw a distinction between organisationally proximate knowledge and organisationally distant knowledge. Organisationally proximate knowledge comes from organisationally proximate partners, such as member companies of the same group, and therefore is shaped by similar assumptions and cultural values, embedded into similar practices and organisational routines, and partially overlapping. Organisationally distant knowledge comes instead from organisationally distant partners, such as fully autonomous firms, and thus is shaped by different assumptions and values, embedded into different organisational mechanisms and routines, and substantively diverse.

Integrating organisationally distant knowledge in R&D alliances has the potential to positively affect innovation. Knowledge diversity is indeed a prerequisite for innovation (e.g. Phene, Fladmoe-Lindquist, and Marsh 2006). Sampson (2007) has observed that the diversity of the partners' knowledge increases the possible number of new recombinations, thereby enhancing the innovative potential of R&D alliances. Conversely, integrating organisationally proximate knowledge in R&D alliances negatively affects the alliance innovative performance. While sharing a stock of common knowledge and the existence of similar knowledge-processing systems and dominant logics can sustain interorganisational knowledge transfer in R&D alliances (Mowery, Oxley, and Silverman 1996; Lane and Lubatkin 1998), too much similarity between the knowledge bases of allied organisations hurts their ability to innovate (Sampson 2007). In fact, organisationally proximate knowledge is typically more technologically local, hence characterised by an intrinsically lower degree of novelty and diversity, than organisationally distant knowledge (Miller, Fern, and Cardinal 2007). Being local knowledge less conducive to innovation (Stuart and Podolny 1996; Rosenkopf and Nerkar 2001), we expect R&D alliances combining organisationally proximate knowledge to be less innovative.

> *Hypothesis 1b*. In R&D alliances, the integration of organisationally proximate knowledge is negatively related to the alliance innovative performance.

2.3. *Search span*

Innovation is a search process (Nelson and Winter 1982) and previous studies have shown that firms use alliances to jointly search for new knowledge (e.g. Powell, Koput, and Smith-Doerr 1996). Focusing on R&D alliances, Capaldo and Messeni Petruzzelli (2011) have introduced the concept of search span to capture the extent to which allied firms jointly search across different knowledge domains. The concept of search span is strictly related to the notion of innovation complexity (Tushman and Rosenkopf 1992; Wonglimpiyarat 2005). Zander and Kogut (1995, 79) argued that knowledge is more complex when it draws upon multiple distinct kinds of competencies. In line with this view, complex innovations combine numerous components drawing on a variety of knowledge bases (Singh 1997; Hobday 1998). Thus, in the case of R&D alliances, the more the innovation complexity, the higher the number of different knowledge areas allied firms have to jointly search across, and hence the broader the span of their search. Previous research has found an inverted U-shaped relationship between search span and alliance-level innovation (Capaldo and Messeni Petruzzelli 2011). In the present study, we focus on the moderating effects of search span and develop the hypotheses that search span positively moderates the negative relationships between the geographic and organisational origins of knowledge and the innovative performance of R&D alliances.

2.3.1. *Search span, geographic origin of knowledge, and the innovative performance of R&D alliances*

Although knowledge from geographically distant contexts can be difficult to understand, transfer, and use, studies contend that firms pursue geographically distant knowledge in order to innovate (Phene, Fladmoe-Lindquist, and Marsh 2006; Capaldo, Lavie, and Messeni Petruzzelli 2015). Sidhu, Commandeur, and Volberda (2007) have found a positive relationship between spatial boundary-spanning search and firm innovativeness in both more and less dynamic environments. Bathelt, Malmberg, and Maskell (2004) have urged firms localised in clusters to enter into extra-local interorganisational relationships with distant partners (i.e. 'pipelines') from which to draw knowledge resources to be combined with those available within the cluster, thereby enhancing innovation (see also: Oerlemans and Meeus 2005; Whittington, Owen-Smith, and Powell 2009). In the field of alliance studies, Shan and Hamilton (1991) argued that firms enter into international cooperative ventures in order to tap into the comparative advantages of their partners' countries, and found technology transfer to be a major motivation for cross-country alliances. In a subsequent study, Rosenkopf and Almeida (2003) contended that, embodying rich media for knowledge transfer, R&D alliances may facilitate the flow of knowledge across spatially distant contexts. Thus, R&D alliances can be effective means for firms to source geographically distant knowledge and, by doing so, to innovate (Hagedoorn 1993). This may seem in contrast with our previous discussion on the liabilities of combining geographically distant knowledge in alliances. However, this apparent contradiction can be reconciled by looking at the objectives and scope of interorganisational collaboration. Specifically, we suggest that allied firms will benefit from the combination of geographically distant knowledge when they are involved in the development of complex innovations, which requires searching across the boundaries of several different knowledge domains.

In fact, while making it difficult for distant partners to interact and to effectively share knowledge, the geographic localisation of knowledge also makes it likely that partners from distant geographic regions possess non-overlapping knowledge bases (Maskell, Bathelt, and Malmberg 2006). In particular, 'inasmuch as useful ideas and knowledge relating to the production, distribution, and selling of goods and services are localised, firms that undertake greater geographic search should have access to *a more varied set of knowledge elements* for recombination' (Sidhu, Commandeur, and Volberda 2007, 23, italics added), which is essential to the innovative performance of R&D alliances aimed at broad-span searching. In such alliances, integrating geographically distant knowledge has the potential to allow partnered firms to overcome their organisational bias towards localised search and its inherent limitations, providing them with the heterogeneous knowledge base needed to search effectively across different knowledge domains (Phene, Fladmoe-Lindquist, and Marsh 2006).

This is coherent with previous research suggesting that, as the number of different specialised inputs needed to complete products or services grows (Jones, Hesterly, and Borgatti 1997), and therefore knowledge creation requires increasingly complex combinations of heterogeneous pieces of knowledge (Teece 1986), the locus of innovation lies in interorganisational collaborative relationships crossing geographic boundaries (Gomes-Casseres 1994; Powell, Koput, and Smith-Doerr 1996). For example, the rapid growth and success of the biotechnology industry, where numerous cross-region R&D collaborations allow complex combinations of knowledge inputs from disciplines as distant as molecular biology, organic chemistry, computer technology, and software development (Shan and Hamilton 1991; DeCarolis and Deeds 1999), substantiate the conjecture that combining geographically distant knowledge in alliances aimed at searching broadly can foster the discovery of novel linkages and associations, so impacting positively innovation at the alliance level.

In addition, extant literature has raised the hazards of inter-partner competition which afflicts interorganisational relationships aimed at integrating geographically proximate knowledge given that geographically proximate partners may in fact compete for the same technological and human resources and for the same customers (e.g. Pouder and St. John 1996), so enhancing the risks that communication barriers and opportunistic behaviours hamper knowledge transfer and combination within the alliance. We suggest that the interorganisational integration of geographically distant knowledge may ameliorate such risks, so influencing positively innovation performance. We expect this to happen specifically in the case of R&D alliances aimed at searching across several different knowledge domains, which requires a higher degree of open-ended and knowledge-intensive cooperation between the participating organisations (Hobday 1998; Capaldo and Messeni Petruzzelli 2011). Thus, we put forward the following hypothesis:

> *Hypothesis 2a*. In R&D alliances, search span positively moderates the relationship between the integration of geographically distant knowledge and the alliance innovative performance.

2.3.2. *Search span, organisational origin of knowledge, and the innovative performance of R&D alliances*

As previously discussed, R&D alliances between organisationally proximate partners typically display low innovative performance because combining organisationally proximate knowledge tends to reduce the diversity of the overall knowledge base at the alliance level. Nevertheless, although pooling heterogeneous knowledge is important for innovation in R&D alliances, a certain degree of similarity between partners can be crucial for effective interorganisational knowledge sharing. Empirical work by Lane and Lubatkin (1998) has shown that partner firms endowed with organisationally proximate knowledge can more easily recognise, assimilate, and apply to commercial ends the other party's knowledge. We note that such a higher relative absorptive capacity is especially important for innovation in alliances aimed at searching broadly, wherein the participating organisations are required to integrate distant (although complementary) knowledge inputs in order to generate complex innovations.

Drawing on Cohen and Levinthal (1990), we observe that, as search span increases, the usual trade-off between diversity and commonality of knowledge between knowledge holders and recipients becomes increasingly crucial in order to allow organisational actors across the boundaries of partnered organisations to effectively learn from each other and co-produce innovation (see also Nooteboom et al. 2007). Thus, when firms form alliances to search across several different knowledge domains to develop complex innovations, the liabilities of the integration of organisationally proximate knowledge tend to be offset by the advantages that organisational proximity offers in terms of a superior relative absorptive capacity. This leads us to believe that integrating organisationally proximate knowledge in R&D alliances aimed at searching broadly exerts beneficial effects on the alliance innovative performance.

Empirical studies focused on settings where broad-span searching is a prerequisite to compete and support this conjecture. For example, Brusoni, Prencipe, and Pavitt (2001) found that, while outsourcing detailed design and manufacturing at the component level to specialised suppliers, system integrator firms that deliver complex, multi-technology products such as aircraft engines sustain their innovative capability at the architectural level by purposefully maintaining a certain degree of cognitive overlap with their supplier network. Capaldo (2007) has showed that, where innovation happens at the crossroads of several different disciplines and knowledge domains, strong tie alliances between firms endowed with similar cultural orientations and organisational routines and with partially overlapping knowledge bases sustain the organisational capability to innovate repeatedly. The above arguments suggest our final hypothesis:

Hypothesis 2b. In R&D alliances, search span positively moderates the relationship between the integration of organisationally proximate knowledge and the alliance innovative performance.

3. Methods

3.1. *Sample*

The hypotheses outlined in previous Sections were tested on a sample of R&D alliances established, between 1998 and 2003, by 10 ‘focal’ companies that we identified as the most innovative in the EEE industry in terms of the number of granted patents by the European Patent Office (EPO) during the selected time-period (Table 1). In order to identify our sample, we pointed to JPs, a specific form of a standard patent jointly filed with a patent office by, and co-assigned to, two or more organisations, which thus share the property rights on a jointly developed invention (Hagedoorn 2003). Extant research has employed JPs as a proxy for interorganisational technological cooperation aimed at innovation (Rocha 1999) and/or to evaluate the resulting outcomes (Kim and Song 2007; Messeni Petruzzelli 2011; Capaldo and Messeni Petruzzelli 2014). Accordingly, we relied on JPs to identify both our sample R&D alliances and gauge their innovative performance. Thus, while the level of analysis of the present study is the alliance, our basic unit of analysis is the individual JP and its associated content.

We gathered all the inter-firm dyadic (i.e. co-assigned to two co-assignee firms) JPs filed at the EPO by the 10 focal companies between 1998 and 2003. Only JPs filed at the EPO were considered. The period 1998–2003 was chosen because the number of JPs started to increase significantly at the end of the 1990s (Hicks and Narin 2001; Hagedoorn 2003). For our purposes here, each selected JP represents an inter-firm dyadic R&D alliance. Thus, 1515 inter-firm dyadic R&D alliances established by the 10 focal companies with 225 different partners were included in our sample.

We deemed it appropriate to test our hypotheses on the sample described above for a number of reasons. First, extant research has shown that firms in the electric and electronic field largely and

Table 1. The focal companies (1998–2003).

Focal company	Headquarter	Total number of patents registered at the EPO	Average annual revenues ($ millions)	Average number of employees
Matsushita	Osaka (Japan)	154,897	77,871	313,594
Hitachi	Tokyo (Japan)	122,438	87,615	360,194
Samsung	Seoul (South Korea)	119,707	89,476	84,721
Toshiba	Tokyo (Japan)	101,781	60,842	204,958
Sony	Tokyo (Japan)	89,749	70,925	185,800
LG	Seoul (South Korea)	81,080	68,754	29,496
Mitsubishi Electric	Tokyo (Japan)	69,652	32,965	108,500
Siemens	Munchen (Germany)	58,888	107,342	428,000
Philips	Eindhoven (Netherlands)	43,206	38,707	128,011
Sharp	Osaka (Japan)	42,107	26,741	54,765

increasingly resort to R&D alliances for innovation purposes (Duysters and Hagedoorn 1996; Oxley and Sampson 2004). In addition, previous scholars have found that patents are effective means for firms to protect their intellectual property in the examined field (Levin et al. 1987; Baudry and Dumont 2006), which supports our choice to rely on patent-based measures of innovative performance. Moreover, the electric and electronic field is among those wherein the largest numbers of JPs have been found in previous studies (Hicks and Narin 2001; Hagedoorn 2003). Finally, while firms still vary considerably in their resort to JPs (Hagedoorn 2003), focusing on highly innovative firms allowed us to obtain a sizeable sample.

3.2. *Variables*

The variables used in the present study are summarised and described in Table 2. In order to measure our dependent variable, we resorted to citation counting. Patent citations have been largely employed to evaluate innovation performance (e.g. Miller, Fern, and Cardinal 2007; Sampson 2007). In particular, previous scholars have shown the number of citations received by patents to be positively related to patent value (Harhoff, Scherer, and Vopel 2003) and that highly cited patents yield higher economic profits (Hall, Jaffe, and Trajtenberg 2005). Thus, we measured the alliance innovative performance by the number of citations each sample JP had received from subsequent patents within five years of the issue date, excluding self-citations of the co-assignees (see also Capaldo and Messeni Petruzzelli 2014). Each JP was assigned an equal five-year moving window to be cited in an attempt to eliminate possible biases in the number of citations received (e.g. Stuart and Podolny 1996). A five-year window was deemed appropriate because knowledge capital tends to lose most of its economic value within five years (Griliches 1979).

We gauged the extent to which R&D alliances integrate geographically distant knowledge by a continuous positive variable expressing the spatial distance, at the city level, between the location sites of the co-assignee firms of the corresponding JPs. We gauged the integration of organisationally proximate knowledge in R&D alliances by a binary variable taking value one if the two co-assignee firms belonged to the same group (i.e. equity stakes existed between them), zero otherwise (e.g. de Faria, Lima, and Santos 2010). Indeed, being organisationally proximate/distant, co-assignee firms belonging/not belonging to the same group were assumed to contribute to their joint innovative endeavour, and so to integrate within their alliances, organisationally proximate/distant knowledge. Information about the existence of equity stakes between the co-assignee firms were collected from multiple data sources including the firms' annual reports and websites, Who Owns Who directories, and the online database World'vest Base.

Following the previous research (Capaldo and Messeni Petruzzelli 2011), we based our measure of search span on the International Patent Classification (IPC). We focused on the IPC class (three-digit) level and measured search span for each sample alliance by the number of IPC classes to which the EPO had assigned the corresponding JP. The higher the number of different IPC classes to which a JP had been assigned, the higher the corresponding number of different knowledge domains the allied organisations were supposed to had searched across, and hence the higher search span at the alliance level.

We incorporated in our models several control variables that may contribute to explain the innovative performance of R&D alliances, including size of both our focal companies and their partners, technological capital of both parties, size of the research team involved in the collaborative project, relatedness between the focal companies' technological capabilities and the collaborative project at hand, technological proximity between the allied firms, and number of

Table 2. Variables.

Variable name	Variable description
Dependent variable	
InnPerf	Number of citations a JP received within five years of the issue date from subsequent patents, excluding self-citations of the co-assignees.
Independent variables	
GeoDistKnowledge	Natural logarithm of the geographic distance (in kilometres) between allied firms.
OrgProxKnowledge	Dummy variable set to one in case of the existence of equity stakes between allied firms.
Moderating variable	
SearchSpan	Number of IPC classes to which the EPO assigned a JP.
Control variables	
FocCompSize	Natural logarithm of the number of employees of the focal company.
PartnerSize	Natural logarithm of the number of employees of the focal company's partner.
FocCompTechCapital	Natural logarithm of the number of patents filed with the EPO by the focal company during the five years prior to a JP issue date (e.g. Nooteboom et al. 2007).
PartTechCapital	Natural logarithm of the number of patents filed with the EPO by the focal company's partner during the five years prior to a JP issue date (e.g. Nooteboom et al. 2007).
TeamSize	Number of inventors involved in the development of a JP.
InnovRelatedness	Dummy variable taking value one if a JP was assigned to a main patent class in which the focal company had patented with the EPO during the five years prior to the JP issue date (e.g. Nooteboom et al. 2007).
TechProximity	Technological proximity between the focal company and its partner expressed by the extent to which they had patented with the EPO in the same technology classes during the five years prior to the issue date of a JP. We obtained it as 1 – the Technological Diversity Index developed by Sampson (2007).
PriorAlliances	Number of JPs jointly filed with the EPO by the focal company and its partner during the five years prior to the issue date of a JP.
Japan	Dummy variable taking value one if the focal company was headquartered in Japan.
SouthKorea	Dummy variably taking value one if the focal company was headquartered in South Korea.
Europe	Dummy variable taking value one if the focal company was headquartered in Europe.
PartnerIndustry	Dummy variable taking value one if the focal company's partner operated in the EEE industry.
Year	Dummy variables indicating a particular year in the observed period 1998–2003 (omitted category = 1998).
FocComp	Dummy variables indicating a particular focal company (omitted category = Philips).

prior R&D alliances between them. We also used dummy variables to control for differences among our focal companies in terms of the countries in which they are headquartered and for diversity between allied firms in terms of the industries in which they operate. Finally, we included year dummies and focal firm dummies in our models.

3.3. *Estimation procedure*

Our dependent variable is a non-negative, integer count variable with overdispersion. We therefore resorted to an extension of the Poisson estimation, that is, the negative binomial. Huber–White robust standard errors were employed to control for heteroskedasticity issues.

4. Results

Table 3 reports descriptive statistics and pairwise correlations for all the variables described above. In Table 4, we present six models from the negative binomial regression. Results are consistent and stable across the models, so our comments below are based on the comprehensive model (Model 6), which includes all the variables and interaction terms. Consistent with our *Hypotheses 1a* and *1b*, the coefficients for *GeoDistKnowledge* and *OrgProxKnowledge* are negative and significant, which confirms that the integration of geographically distant knowledge and of organisationally proximate knowledge in R&D alliances exert a negative influence on the alliance innovative performance. Moreover, consistent with our *Hypotheses 2a* and *2b*, both the interaction terms *GeoDistKnowledgeXSearchSpan* and *OrgProxKnowledgeXSearchSpan* are positive and significant, thus confirming that integrating geographically distant knowledge, as well as organisationally proximate knowledge, in R&D alliances aimed at searching broadly exerts a positive influence on the alliance innovative performance.[1]

Interestingly, our findings suggest that the moderating effects of search span on the relationships between the integration of geographically distant/organisationally proximate knowledge in R&D alliances and the alliance innovative performance are substantial. In our sample, when the alliance search span is at its maximum (i.e. six), integrating the knowledge of partners at maximum geographic distance (i.e. 14,482 km.) increases the alliance innovative performance by about 8.5 times when compared to integrating the knowledge of partners at minimum geographic distance, and integrating organisationally proximate knowledge increases the alliance innovative performance by about 2.7 times when compared to integrating organisationally distant knowledge.

To gain more insight into the relationships between search span, the origins of knowledge, and the innovative performance of R&D alliances, we now look at the three variables simultaneously. We consider all the values that search span assumes in our sample (i.e. one through six) and estimate the effect of the integration of geographically distant knowledge on the alliance innovative performance for all of them. We do so by focusing on two different scenarios, in which the parties combine organisationally proximate knowledge and organisationally distant knowledge, respectively. The results for the two scenarios are depicted in Figure 2(a) and 2(b). The two figures show similar trends. In both scenarios, as the geographic distance of knowledge increases, the alliance innovative performance decreases slowly when search span is at its minimum, while growing at an increasingly higher rate as search span grows from two to six.

Taken together, the two figures suggest that, when allied firms search within one single knowledge domain, combining geographically distant rather than proximate knowledge and combining organisationally proximate rather than distant knowledge have a slightly negative, almost negligible impact on the alliance innovative performance. Conversely, when allied firms search across even the minimum possible number of different knowledge domains (i.e. *SearchSpan* ≥ 2), the more geographically distant the knowledge resources integrated within the alliance, the more the alliance innovative performance. Moreover, the higher the search span, the higher such positive effect. Interestingly, this results hold irrespective of whether the combined knowledge is

Table 3. Descriptive statistics and bivariate correlation matrix.[a]

Variables	Mean	Std.Dev.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. InnPerf	0.55	1.56	0.00	21.00	1.00															
2. SearchSpan	1.44	0.70	1.00	6.00	0.03	1.00														
3. GeoDistKnolwedge [b]	6.59	1.54	1.61	9.58	0.09	0.03	1.00													
4. OrgProxKnolwedge	0.45	0.50	0.00	1.00	0.17	0.02	0.02	1.00												
5. FocCompSize [b]	12.07	0.71	10.29	12.97	– 0.03	– 0.05	– 0.22	0.02	1.00											
6. PartnerSize [b]	7.82	2.54	5.56	11.38	– 0.01	0.02	0.08	– 0.21	0.32	1.00										
7. FocCompTechCapital [b]	10.60	0.62	8.43	11.65	– 0.28	0.05	– 0.20	– 0.39	0.40	0.09	1.00									
8. PartTechCapital [b]	7.11	2.56	0.00	12.40	– 0.03	0.03	– 0.01	0.02	0.06	0.38	0.04	1.00								
9. TeamSize	3.31	2.43	2.00	10.00	– 0.10	0.07	0.06	0.10	– 0.03	0.41	0.13	0.43	1.00							
10. InnovRelatedness	0.78	0.17	0.00	1.00	0.40	– 0.02	– 0.08	0.21	0.30	– 0.20	– 0.19	– 0.01	– 0.11	1.00						
11. TechProximity	0.47	0.27	0.00	0.96	0.07	0.02	– 0.04	0.03	– 0.11	– 0.01	– 0.00	0.05	– 0.02	0.12	1.00					
12. PriorAlliances	4.37	2.18	1.00	8.00	0.03	0.13	– 0.01	0.05	0.21	– 0.02	0.10	0.17	– 0.02	0.21	0.29	1.00				
13. Japan	0.49	0.50	0.00	1.00	– 0.01	0.07	– 0.31	0.34	0.12	0.18	0.41	0.02	0.02	0.07	0.20	0.26	1.00			
14. SouthKorea	0.09	0.30	0.00	1.00	– 0.01	– 0.02	– 0.16	0.21	0.16	0.08	0.32	0.05	0.03	0.08	0.11	– 0.06	– 0.42	1.00		
15. Europe	0.42	0.49	0.00	1.00	0.04	0.13	0.27	0.38	0.22	0.11	0.27	– 0.04	– 0.09	0.11	– 0.25	0.33	– 0.75	– 0.44	1.00	
16. PartnerIndustry	0.67	0.23	0.00	1.00	0.26	– 0.24	– 0.13	0.09	0.21	– 0.08	0.38	0.05	– 0.12	0.37	0.14	0.26	0.36	0.31	0.18	1.00

[a] $N = 1515$.
[b] Variables are logged.

Table 4. Regression results.

Dependent variable: InnPerf		Model 1 (negative binomial – baseline)	Model 2 (negative binomial)	Model 3 (negative binomial)	Model 4 (negative binomial)	Model 5 (negative binomial)	Model 6 (negative binomial – comprehensive)
Independent variables							
GeoDistKnowledge[a]	*H1a*		– 0.17 (0.09) **		– 0.14 (0.05) **		– 0.13 (0.07) **
OrgProxKnowledge	*H1b*			– 0.22 (0.05) ***		– 0.18 (0.04) ***	– 0.16 (0.04) ***
SearchSpan					0.40 (0.21) **	0.36 (0.19) **	0.26 (0.14) **
SearchSpan^2					– 0.09 (0.05) **	– 0.07 (0.03) **	– 0.07 (0.03) **
GeoDistKnowledge[a] X SearchSpan	*H2a*				0.12 (0.06) **		0.10 (0.05) **
OrgProxKnowledge X SearchSpan	*H2b*					0.15 (0.07) **	0.12 (0.06) **
Control variables							
FocCompSize[a]		– 1.19 (0.28) ***	– 1.17 (0.27) ***	– 1.16 (0.27) ***	– 1.13 (0.26) ***	– 1.11 (0.26) ***	– 1.09 (0.26) ***
PartnerSize		– 1.05 (1.00)	– 0.97 (0.90)	– 1.01 (0.93)	– 0.95 (0.90)	– 0.96 (0.90)	– 0.93 (0.90)
FocCompTechCapital[a]		0.13 (0.07) **	0.11 (0.05) **	0.11 (0.05) **	0.11 (0.06) **	0.11 (0.06) **	0.08 (0.04) **
PartTechCapital[a]		– 0.01 (0.01)	– 0.01 (0.01)	– 0.01 (0.01)	– 0.01 (0.01)	– 0.01 (0.01)	– 0.01 (0.01)
TeamSize		– 0.01 (0.00)	– 0.01 (0.00)	– 0.01 (0.00)	– 0.01 (0.00)	– 0.01 (0.00)	– 0.01 (0.00)
InnovRelatedness		0.64 (0.33) **	0.50 (0.25) **	0.59 (0.29) **	0.46 (0.24) **	0.48 (0.25) **	0.46 (0.24) **
TechProximity		0.14 (0.25) *	0.11 (0.25)	0.11 (0.25)	0.10 (0.21)	0.10 (0.21)	0.08 (0.20)
PriorAlliances		0.18 (0.11) *	0.13 (0.07) *	0.13 (0.07) *	0.12 (0.07) *	0.11 (0.07) *	0.09 (0.05) *
Japan		– 0.02 (0.10)	– 0.02 (0.10)	– 0.01 (0.10)	– 0.01 (0.10)	– 0.01 (0.10)	– 0.01 (0.10)
SouthKorea		– 0.03 (0.17)	– 0.03 (0.16)	– 0.03 (0.16)	– 0.03 (0.17)	– 0.03 (0.16)	– 0.03 (0.16)
PartnerIndustry		0.21 (0.12) *	0.19 (0.10) *	0.17 (0.09) *	0.15 (0.08) *	0.15 (0.08) *	.15 (0.08) *
Year dummies (5)		4 years ***	4 years ***	4 years ***	4 years ***	4 years ***	4 years ***
FocComp dummies (9)		8 companies **	8 companies **	8 companies **	8 companies **	8 companies **	8 companies **
Log pseudo-likelihood		– 2110.52	– 2105.35	– 2103.47	– 2071.47	– 2067.71	– 2064.28
Improvement over Base ($\Delta\ \chi^2$)		–	5.17	7.05	39.05	42.81	46.24
No. of Obs.		1515	1515	1515	1515	1515	1515

Note: Huber–White robust standard errors are reported in parentheses.
[a]Variables are logged.
*$p < .05$.
**$p < .01$.
***$p < .001$.

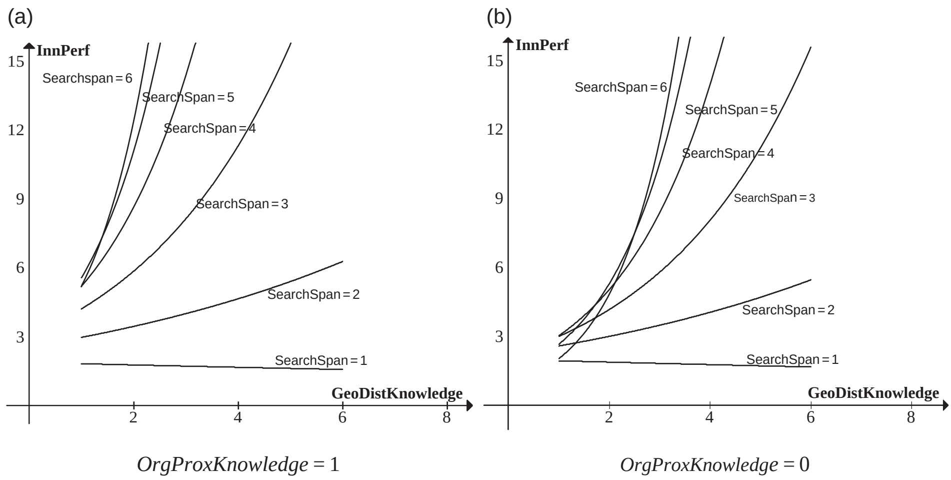

Figure 2. Moderating effects of search span.

organisationally proximate or distant. However, our analysis also shows that integrating organisationally proximate knowledge in R&D alliances aimed at searching across different knowledge domains strengthens the positive relationship between the integration of spatially distant knowledge and the alliance innovative performance to a non-trivial extent. For example, in our sample, when search span is at its maximum, as the geographic distance of knowledge increases from its minimum to its maximum, the alliance innovative performance grows by about 10 times when the combined knowledge is organisationally proximate, while growing by about eight times when it is organisationally distant.

4.1. *Robustness tests*

We conducted several auxiliary analyses to test the robustness of our findings. First, we measured our dependent variable by including self-citations and controlling for their number. Second, we measured search span at the IPC section level (1-digit). Third, we run fixed effects Poisson regression. Fourth, in order to deal with the ‘excess zero’ issue afflicting our data, following previous scholars (Trajtenberg 1990) we tested our hypotheses by adding one to the number of citations each sample JP had received within five years of the issue date. All these robustness tests confirmed our results.

5. Discussion and conclusion

Our research had two objectives. First, we aimed at shedding more light on the influence of the geographic and organisational origins of knowledge on innovative performance. Second, we aimed at ascertaining the moderating effect of search span on the relationships between the geographic and organisational origins of knowledge and innovative performance. We pursued the two objectives at the interorganisational level of analysis, specifically in the context of R&D alliances, which have become in recent years an open innovation practice widely adopted by firms.

Our findings reveal that integrating geographically distant as well as organisationally proximate knowledge in R&D alliances negatively affects innovative performance at the alliance level. On the one hand, allied firms find it difficult to understand, and exploit the innovative potential of, the spatially distant knowledge. On the other hand, combining knowledge shaped by similar assumptions and cultural values, embedded into similar practices and organisational routines, and partially overlapping, reduces the innovative potential of R&D alliances.

However, we have argued that considering the characteristics of the innovation process, and in particular how firms search for new knowledge, may significantly enrich our understanding of the relationships between knowledge origins and innovative performance. Indeed, our findings show that simultaneous consideration of both the search span and the origins of knowledge subverts the conclusions illustrated above. The more allied firms search across different knowledge areas, the more integrating geographically distant, as well as organisationally proximate, knowledge across their boundaries positively affects the innovative performance of R&D alliances. On the one hand, combining geographically distant knowledge helps firms participating in R&D alliances to overcome their organisational bias towards localised search and its inherent limitations, providing them with the heterogeneous knowledge base needed for broad-span searching. On the other hand, when combining organisationally proximate knowledge, allied firms benefit from a higher relative absorptive capacity, that is particularly important for innovation in R&D alliances aimed at searching broadly.

These results are especially relevant in the light of the firms' tendency to embark in alliances to respond to growing competition and increasingly multifaceted customer needs, which calls for complex innovations (Teece 1986; Tether 2002). Developing complex innovations asks indeed for combining numerous components drawing on a variety of knowledge bases (Singh 1997; Hobday 1998), which in turn implies searching across several different knowledge domains. We thus contend that integrating geographically distant knowledge and organisationally proximate knowledge in R&D alliances can help allied firms to overcome the challenges inherent in developing more complex innovations, spanning multiple knowledge domains.

Further implications of the present study emerge from our additional analysis considering the three examined variables simultaneously, which suggests that, when searching narrowly (i.e. within one single knowledge domain), firms involved in R&D alliances need not be especially worried about the geographic and organisational origins of the knowledge resources they integrate within their alliances. Conversely, when searching across different knowledge domains, allied firms can make the most of broad-span searching by integrating geographically distant but organisationally proximate knowledge. By doing so, firms take advantage of the diversity and novelty that characterises geographically distant knowledge, while preserving considerable levels of 'relative absorptive capacity' (Lane and Lubatkin 1998; Schildt, Thomas, and Maula 2013) that are needed for them to understand, internalise, and effectively use partners' knowledge from different domains.

We close this paper by outlining some other contributions of our research and its major limitations. First, this study contributes to the extant innovation literature that has investigated the processes by which firms search for new knowledge (Rosenkopf and Nerkar 2001; Katila and Ahuja 2002; Laursen 2012). Focusing on the recently introduced concept of search span (Capaldo and Messeni Petruzzelli 2011), we have pushed it further by unveiling its moderating effect on the relationships between knowledge origins and innovative performance.

Second, whereas previous research has examined the impact exerted on innovation performance by either the origins of knowledge (McFadyen and Cannella 2005; Phene, Fladmoe-Lindquist, and Marsh 2006) or several characteristics of the search process (Katila and Ahuja

2002; Laursen and Salter 2006; Capaldo and Messeni Petruzzelli 2011), our findings suggest that considering the two aspects separately may be misleading. We have shown that, in the case of R&D alliances, the influence of the geographic and organisational origins of the partners' knowledge on the alliance innovative performance is contingent upon the alliance search span. Based on this, while we agree with previous literature that the knowledge base of potential partners matters for innovation in alliances, and therefore should offer the basis for partner selection (Mowery, Oxley, and Silverman 1998; Hitt et al. 2000), we also concur with those who have argued that the criteria used by managers to choose alliance partners should vary depending on the specific alliance task (Shah and Swaminathan 2008). We thus caution firms participating in R&D alliances against selecting their partners without considering the characteristics of the innovative activities to be performed within the alliance. Specifically, we advocate for careful partner selection on the basis of how broadly the allied organisations are expected to search.

Third, although the alliance (or the alliance network) has been acknowledged as an increasingly important unit of analysis for strategy and organisation scholars (Dyer and Singh 1998), it is typically used to draw conclusions at the firm level, and in particular to investigate the determinants of firm performance, innovativeness, and competitive advantage (e.g. Baum, Calabrese, and Silverman 2000; Sampson 2007; Koka and Prescott 2008). Conversely, this study has focused on alliances to investigate the determinants of innovative performance at the alliance level. By doing so, it adds to a body of research aimed at clarifying the alliance-level antecedents of strategic alliance outcomes (e.g. Lane, Salk, and Lyles 2001; Krishnan, Martin, and Noorderhaven 2006). To those interested in this literature, and in alliance research more generally, this study offers another possible contribution. Gulati (1998) observed that, while being one of the most exciting areas of alliance research, alliance performance remains largely unexplored because of some onerous research obstacles including measuring performance at the alliance level and collecting data. In order to contribute to tackle these challenges, we propose to use JPs to not only identify R&D alliances, but also gauge the alliances' innovative performance by the number of citations received by the JPs. The large availability of patent data and the increasing resort to JPs by collaborating firms can make JPs useful tools for future research on alliances.

5.1. *Implications for the open innovation literature*

Our study has relevant implications for the growing literature on open innovation (e.g. Chesbrough 2003; Dahlander and Gann 2010).[2] Extant research has focused on the breadth and depth of openness, that is, respectively, on the number of external sources of knowledge that firms rely upon in their innovative activities, and on the extent to which firms draw deeply from that sources (Laursen and Salter 2006). We submit that another relevant dimension of the open innovation construct lays in the degree of openness, which refers to the organisational proximity of the external knowledge sources firms rely upon in their innovative activities. While sourcing knowledge from organisationally proximate sources represents a low-openness external search strategy, drawing on knowledge from organisationally distant sources is a high-openness strategy.

Our findings suggest that both the degree of openness and the characteristics of the innovative task to be performed may influence the impact of the adoption of open innovation strategies on innovation outcomes. Innovation strategies characterised by a low degree of openness, such as those based on the establishment of R&D alliances with member companies of a same group, may be detrimental to innovation. Indeed, low-openness strategies may not allow firms to fully experience the benefits of accessing knowledge elements characterised by high variety and diversity, which typically lies at the heart of firms' recourse to external sources of knowledge and has been found to be positively related to innovation outcomes (Rosenkopf and Nerkar 2001; Sampson 2007). However, when firms resort to open innovation logics in order to develop complex innovations, a lower degree of openness may be conducive to higher innovative performance, being it able to offset the limits that relative absorptive capacity considerations may impose on the adoption of high-openness innovation strategies for broad-span searching purposes. Along this way, our study may contribute to shifting attention, within the open innovation literature, from the breadth and depth of openness (e.g. Laursen and Salter 2006; Love, Roper, and Vahter 2013) to its degree, and in particular to shed light on the contingencies under which more versus less open practices can be more beneficial to innovation.

Another stream of research within the open innovation paradigm has focused on the characteristics and outcomes of different governance modes for external knowledge sourcing, such as markets, partnerships, and mergers and acquisitions (e.g. Felin and Zenger 2014). When viewed under the lens of this literature, our study has focused on some of the contingencies which may influence the innovative outcomes of a specific governance mode, that is, R&D alliances. Future researchers may want to test the robustness of our conclusions under different governance modes, so deepening our knowledge of the similarities and differences between such modes and of the conditions under which the different modes may be more or less conducive to innovation.

5.2. *Limitations*

Our study has some limitations that should be considered when interpreting its results. First, we included in our sample only the alliances that had generated positive innovation output. This introduced a success bias in our analysis. Moreover, the use of JPs to identify the sample alliances further biased sample selection by excluding from our study alliances that, although successful, did not yield JPs. Second, patenting is a coarse measure of firms' innovative activity and output. In particular, insofar as negative citations (Nerkar 2003) and examiners-added citations (Alcácer and Gittelman 2006) are common practice, counting forward citations may overestimate the innovative performance. Third, care must be taken to generalise our findings to different types of alliances and different industry settings. In fact, the geographic and organisational origins of the partners' knowledge may be less important in alliances other than R&D, such as logistics, manufacturing, or distribution alliances. In addition, the results herein are more relevant to medium-to-high-tech industries such as the EEE industry, where innovative outcomes are critical to alliance success, than to low-to-medium-tech industries.

Acknowledgements

We thank Dovev Lavie for useful suggestions. Earlier versions of this study were presented at the 2009 DRUID Society Conference, 17–19 June, Copenhagen, and at a Research Seminar at the University Institute of Lisbon (ISCTE-IUL), Business Research Unit, 8 February 2013, Lisbon.

Notes

1. Note that the effect of search span on the dependent variable is inverted U-shaped. In an analysis not reported here, we also tested the quadratic terms of both our independent variables (i.e. *GeoDistKnowledge* and *OrgProxKnowledge*^{2}), as well as their interaction terms with the quadratic term of search span (i.e. *GeoDistKnowledge*^{2}*XSearchSpan*^{2} and *OrgProxKnowledge*^{2}*XSearchSpan*^{2}). In all these cases, the results turned out to be not statistically significant.
2. We thank an anonymous reviewer for having encouraged us to read our findings under the lens of the open innovation literature and for his/her useful suggestions.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Antonio Capaldo is Associate Professor of Strategic Management at the Catholic University of the Sacred Heart, Milan and Rome (Italy), S.E.GEST.A. Department of Management. He earned his Ph.D. in Strategy and Organization from the University of Bologna and has been a Visiting Research Fellow at Warwick Business School (UK). Dr. Capaldo's research interests include innovation management, strategic alliances and networks, and the processes of interorganisational collaboration. He also researches in design management, supply chain issues, and cross-cultural management. He has published extensively on these topics in various academic journals including *Strategic Management Journal*, *Journal of Management*, *European Management Review*, *Industrial Marketing Management*, *Scandinavian Journal of Management*, and *The Global Community*.

Antonio Messeni Petruzzelli is Lecturer in Innovation Management at Politecnico di Bari (Italy) and co-founder of the Innovation Management Group. He holds a Ph.D. in Management from the Politecnico di Bari and has been a visiting scholar at IESE Business School. His research interests concern innovation management, including themes such as knowledge creation and transfer, interorganisational relationships, and system dynamics modeling. In these topics he has published several articles on international journals and presented papers at international conferences.

References

Ahuja, G. 2000. "The Duality of Collaboration: Inducements and Opportunities in the Formation of Interfirm Linkages." *Strategic Management Journal* 21: 317–343.

Alcácer, J., and M. Gittelman. 2006. "Patent Citations as a Measure of Knowledge Flows: The Influence of Examiner Citations." *The Review of Economics and Statistics* 88: 774–779.

Almeida, P., and B. Kogut. 1999. "Localization of Knowledge and the Mobility of Engineers in Regional Networks." *Management Science* 45: 905–917.

Bathelt, H., M. Malmberg, and P. Maskell. 2004. "Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation." *Progress in Human Geography* 28: 31–56.

Baudry, M., and B. Dumont. 2006. "Comparing Firms' Triadic Patent Applications Across Countries: Is there a Gap in Terms of R&D Effort or a Gap in Terms of Performances?" *Research Policy* 35: 324–342.

Baum, J. A. C., T. Calabrese, and B. S. Silverman. 2000. "Don't Go It Alone. Alliance Network Composition and Startup's Performance in Canadian Biotechnology." *Strategic Management Journal* 21: 267–294.

Boschma, R. A. 2005. "Proximity and Innovation: A Critical Assessment." *Regional Studies* 39: 61–74.

Brown, S., and K. M. Eisenhardt. 1995. "Product Development: Past Research, Present Findings, and Future Directions." *Academy of Management Review* 20: 343–378.

Brusoni, S., A. Prencipe, and K. Pavitt. 2001. "Knowledge Specialization, Organizational Coupling, and the Boundaries of the Firm: Why Do Firms Know More Than They Make?" *Administrative Science Quarterly* 46: 597–621.

Cantwell, J. 1989. *Technological Innovations and Multinational Corporations*. Cambridge, MA: Blackwell.

Capaldo, A. 2007. "Network Structure and Innovation: The Leveraging of a Dual Network as a Distinctive Relational Capability." *Strategic Management Journal* 28: 585–608.

Capaldo, A., D. Lavie, and A. Messeni Petruzzelli. 2015. "Knowledge Maturity and the Scientific Value of Innovations: The Roles of Knowledge Distance and Adoption." *Journal of Management*. doi:10.1177/0149206314535442

Capaldo, A., and A. Messeni Petruzzelli. 2011. "In Search of Alliance-Level Relational Capabilities: Balancing Innovation Value Creation and Appropriability in R&D Alliances." *Scandinavian Journal of Management* 27: 273–286.

Capaldo, A., and A. Messeni Petruzzelli. 2014. "Partner Geographic and Organizational Proximity and the Innovative Performance of Knowledge-Creating Alliances." *European Management Review* 11: 63–84.

Chesbrough, H. 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.

Coff, R. 2003. "Bidding Wars Over R&D-Intensive Firms: Knowledge, Opportunism, and the Market for Corporate Control." *Academy of Management Journal* 46: 74–85.

Cohen, W., and D. A. Levinthal. 1990. “Absorptive Capacity: A New Perspective on Learning and Innovation.” *Administrative Science Quarterly* 35: 128–152.

Crossan, M. M., and M. Apaydin. 2010. “A Multi-Dimensional Framework of Organizational Innovation: A Systematic Review of the Literature.” *Journal of Management Studies* 47: 1154–1191.

Dahlander, L., and D. M. Gann. 2010. “How Open is Innovation?” *Research Policy* 39: 699–709.

DeCarolis, D. M., and D. L. Deeds. 1999. “The Impact of Stocks and Flows of Organizational Knowledge on Firm Performance: An Empirical Investigation of the Biotechnology Industry.” *Strategic Management Journal* 20: 953–968.

Duysters, G., and J. Hagedoorn. 1996. “Internationalization of Corporate Technology Through Strategic Partnering: An Empirical Investigation.” *Research Policy* 25: 1–12.

Dyer, J. H., and K. Nobeoka. 2000. “Creating and Managing a High Performance Knowledge-Sharing Network: The Toyota Case.” *Strategic Management Journal* 21: 345–367.

Dyer, J. H., and H. Singh. 1998. “The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage.” *Academy of Management Review* 23: 660–679.

de Faria, P., F. Lima, and R. Santos. 2010. “Cooperation in Innovation Activities: The Importance of Partners.” *Research Policy* 39: 1082–1092.

Felin, T., and T. R. Zenger. 2014. “Closed or Open Innovation? Problem Solving and the Governance Choice.” *Research Policy* 43: 914–925.

Fleming, L., and O. Sorenson. 2001. “Technology as a Complex Adaptive System: Evidence from Patent Data.” *Research Policy* 30: 1019–1039.

Ganesan, S., A. J. Malter, and A. Rindfleisch. 2005. “Does Distance Still Matter? Geographic Proximity and New Product Development.” *Journal of Marketing* 69: 44–60.

Gertler, M. S. 1995. “‘Being there’: Proximity, Organization, and Culture in the Development and Adoption of Advanced Manufacturing Technologies.” *Economic Geography* 71: 1–26.

Gertler, M. S. 2001. “Best Practice? Geography, Learning and the Institutional Limits to Strong Convergence.” *Journal of Economic Geography* 1: 5–26.

Gomes-Casseres, B. 1994. “Group Versus Group: How Alliance Networks Compete.” *Harvard Business Review* 72: 62–74.

Gomes-Casseres, B., J. Hagedoorn, and A. B. Jaffe. 2006. “Do Alliances Promote Knowledge Flows?” *Journal of Financial Economics* 80: 5–33.

Griliches, Z. 1979. “Issues in Assessing the Contribution of Research and Development to Productivity Growth.” *Bell Journal of Economics* 10: 92–116.

Gulati, R. 1998. “Alliances and Networks.” *Strategic Management Journal* 19: 293–317.

Hagedoorn, J. 1993. “Understanding the Rationale of Strategic Technology Partnering: Interorganizational Modes of Cooperation and Sectoral Differences.” *Strategic Management Journal* 14: 371–385.

Hagedoorn, J. 2003. “Sharing Intellectual Property Rights–An Exploratory Study of Joint Patenting amongst Companies.” *Industrial and Corporate Change* 5: 1035–1050.

Hall, B. H., A. B. Jaffe, and M. Trajtenberg. 2005. “Market Value and Patent Citations.” *RAND Journal of Economics* 36: 16–38.

Harhoff, D., F. M. Scherer, and K. Vopel. 2003. “Citations, Family Size, Opposition and the Value of Patent Rights.” *Research Policy* 32: 1343–1363.

Hicks, D., and F. Narin. 2001. “Strategic Research Alliances and 360 Degree Bibliometric Indicators.” In *Strategic Research Partnerships*, edited by J. E. Jankowski, A. N. Link, and N. S. Vonortas. Proceedings from an NSF Workshop. Arlington, VA: National Science Foundation, Division of Science Resources Studies, NSF 01-336. http://www.nsf.gov/statistics/nsf01336/p1s6.htm.

Hitt, M. A., M. T. Dacin, E. Levitas, J. Arregle, and A. Borza. 2000. “Partner Selection in Emerging and Developed Market Contexts: Resource-Based and Organizational Learning Perspective.” *Academy of Management Journal* 43: 449–467.

Hoang, H., and F. T. Rothaermel. 2005. “The Effect of General and Partner-Specific Alliance Experience on Joint R&D Project Performance.” *Academy of Management Journal* 48: 332–345.

Hobday, M. 1998. “Product Complexity, Innovation and Industrial Organization.” *Research Policy* 26: 689–710.

Jaffe, A. B., M. Trajtenberg, and R. Henderson. 1993. “Geographic Localization of Knowledge Spillovers as Evidence by Patent Citations.” *The Quarterly Journal of Economics* 108: 577–598.

Jiang, X., and Y. Li. 2009. “An Empirical Investigation of Knowledge Management and Innovative Performance: The Case of Alliances.” *Research Policy* 38: 358–368.

Jones, C., W. S. Hesterly, and S. P. Borgatti. 1997. "A General Theory of Network Governance: Exchange Conditions and Social Mechanisms." *Academy of Management Review* 22: 911–945.

Katila, R., and G. Ahuja. 2002. "Something Old, Something New: A Longitudinal Study of Search Behavior and New Product Introduction." *Academy of Management Journal* 45: 1183–1194.

Khanna, T., R. Gulati, and N. Nohria. 1998. "The Dynamics of Learning Alliances: Competition, Cooperation, and Relative Scope." *Strategic Management Journal* 19: 193–210.

Kim, C., and J. Song. 2007. "Creating New Technology Through Alliances: An Empirical Investigation of Joint Patents." *Technovation* 27: 461–470.

Knoben, J., and L. A. G. Oerlemans. 2006. "Proximity and Inter-Organizational Collaboration: A Literature Review." *International Journal of Management Reviews* 8: 71–89.

Kogut, B., and U. Zander. 1992. "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology." *Organization Science* 3: 383–397.

Koka, B. R., and J. E. Prescott. 2008. "Designing Alliance Networks: The Influence of Network Position, Environmental Change, and Strategy on Firm Performance." *Strategic Management Journal* 29: 639–661.

Krishnan, R., X. Martin, and N. Noorderhaven. 2006. "When does Trust Matter to Alliance Performance?" *Academy of Management Journal* 49: 894–917.

Lane, P. J., and M. Lubatkin. 1998. "Relative Absorptive Capacity and Interorganizational Learning." *Strategic Management Journal* 19: 461–477.

Lane, P. J., J. E. Salk, and M. A. Lyles. 2001. "Absorptive Capacity, Learning, and Performance in International Joint Ventures." *Strategic Management Journal* 22: 1139–1161.

Laursen, K. 2012. "Keep Searching and you'll Find: What Do We Know about Variety Creation Through Firms' Search Activities for Innovation?" *Industrial and Corporate Change* 21: 1181–1220.

Laursen, K., and A. Salter. 2006. "Open for Innovation: The Role of Openness in Explaining Innovation Performance Among UK Manufacturing Firms." *Strategic Management Journal* 27: 131–150.

Lawson, C., and E. Lorenz. 1999. "Collective Learning, Tacit Knowledge and Regional Innovative Capacity." *Regional Studies* 33: 305–17.

Levin, R. C., A. K. Klevorick, R. R. Nelson, and S. G. Winter. 1987. "Appropriating the Returns from Industria1 Research and Development." *Brookings Papers on Economic Activity* 3: 783–820.

Levinthal, D., and J. March. 1993. "The Myopia of Learning." *Strategic Management Journal* 14: 95–113.

Love, J. H., S. Roper, and P. Vahter. 2013. "Learning from Openness: The Dynamics of Breadth in External Innovation Linkages." *Strategic Management Journal* 31: 224–236.

March, J. 1991. "Exploration and Exploitation in Organizational Learning." *Organization Science* 2: 71–87.

Maskell, O., H. Bathelt and A. Malmberg. 2006. "Building Global Knowledge Pipelines: The Role of Temporary Clusters." *European Planning Studies* 14: 997–1013.

Maskell, P. and A. Malmberg. 1999. "Localized Learning and Industrial Competitiveness." *Cambridge Journal of Economics* 23: 167–186.

McFadyen, M. A., and A. A. Cannella. 2005. "Knowledge Creation and the Location of University Research Scientists' Interpersonal Exchange Relations: Within and Beyond the University." *Strategic Organization* 3: 131–155.

Messeni Petruzzelli, A. 2011. "The Impact of Technological Relatedness, Prior Ties, and Geographical Distance on University-Industry Collaborations: A Joint Patent Analysis." *Technovation* 31: 309–319.

Miller, D. J., M. J. Fern, and L. B. Cardinal. 2007. "The Use of Knowledge for Technological Innovation within Diversified Firms." *Academy of Management Journal* 50: 307–326.

Mowery, D. C., J. E. Oxley, and B. S. Silverman. 1996. "Strategic Alliances and Inter-Firm Knowledge Transfer." *Strategic Management Journal* 17: 77–91.

Mowery, D. C., J. E. Oxley, and B. S. Silverman. 1998. "Technological Overlap and Interfirm Cooperation: Implications for the Resource-Based View of the Firm." *Research Policy* 27: 507–523.

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

Nerkar, A. 2003. "Old is Gold? The Value of Temporal Exploration in the Creation of New Knowledge." *Management Science* 49: 211–229.

Nooteboom, B. 2009. *A Cognitive Theory of the Firm: Learning, Governance and Dynamic Capabilities*. Cheltenham: Edward Elgar.

Nooteboom, B., W. Vanhaverbeke, G. Duysters, V. Gilsing, and A. van den Oord. 2007. "Optimal Cognitive Distance and Absorptive Capacity." *Research Policy* 36: 1016–1034.

Oerlemans, L. A. G., and M. T. H. Meeus. 2005. "Do Organizational and Spatial Proximity Impact on Firm Performance?" *Regional Studies* 39: 89–104.

Oxley, J. E., and R. C. Sampson. 2004. "The Scope and the Governance of International R&D Alliances." *Strategic Management Journal*, 25: 723–749.

Phene, A., K. Fladmoe-Lindquist, and L. Marsh. 2006. "Breakthrough Innovations in the U.S. Biotechnology Industry: The Effects of Technological Space and Geographic Origin." *Strategic Management Journal* 27: 369–388.

Porter, M. E. 1990. *The Competitive Advantage of Nations*. New York: Free Press.

Pouder, R., and C. H. St. John. 1996. "Hot Spots and Blind Spots: Geographical Clusters of Firms and Innovation." *Academy of Management Review* 21: 1192–1225.

Powell, W. W., K. W. Koput, and L. Smith-Doerr. 1996. "Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology." *Administrative Science Quarterly* 21: 116–145.

Reuer, J. J., and N. Lahiri. 2014. "Searching for Alliance Partners: Effects of Geographic Distance on the Formation of R&D Collaborations." *Organization Science* 25: 283–298.

Ritala, P., and L. Sainio. 2013. "Coopetition for Radical Innovation: Technology, Market and Business-Model Perspectives." *Technology Analysis and Strategic Management* 26: 155–169.

Rocha, F. 1999. "Interfirm Technological Cooperation: Effects of Absorptive Capacity, Firm Size, and Specialization." *Economics of Innovation and New Technology* 8: 253–271.

Romo, F. P., and M. Schwartz. 1995. "The Structural Embeddedness of Business Decisions: The Migration of Manufacturing Plants in New York State, 1960 to 1985." *American Sociological Review* 60: 874–907.

Rosenkopf, L., and P. Almeida. 2003. "Overcoming Local Search Through Alliances and Mobility." *Management Science* 49: 751–766.

Rosenkopf, L., and A. Nerkar. 2001. "Beyond Local Search: Boundary-Spanning, Exploration, and Impact in the Optical Disc Industry." *Strategic Management Journal* 22: 287–306.

Sakakibara, M. 1997. "Heterogeneity of Firm Capabilities and Cooperative Research and Development: An Empirical Examination of Motives." *Strategic Management Journal* 18: 143–164.

Sampson, R. C. 2007. "R&D Alliances and Firm Performance: The Impact of Technological Diversity and Alliance Organization on Innovation." *Academy of Management Journal* 50: 364–386.

Saxenian, A. 1994. *Regional Advantage. Culture and Competition in Silicon Valley and Route 128*. Cambridge: Harvard University Press.

Schildt, H., K. Thomas, and M. Maula. 2013. "The Temporal Effects of Relative and Firm-Level Absorptive Capacity on Interorganizational Learning." *Strategic Management Journal* 33: 1154–1173.

Schilling, M. A. 2009. "Understanding the Alliance Data." *Strategic Management Journal* 30: 233–260.

Schumpeter, J. 1934. *Theory of Economic Development*. Cambridge: Harvard University Press.

Shan, W., and W. Hamilton. 1991. "Country-Specific Advantage and International Cooperation." *Strategic Management Journal* 12: 419–432.

Shah, R. H., and V. Swaminathan. 2008. "Factors Influencing Partner Selection in Strategic Alliances: The Moderating Role of Alliance Context." *Strategic Management Journal* 29: 471–494.

Sidhu, J. S., H. R. Commandeur, and H. W. Volberda. 2007. "The Multifaceted Nature of Exploration and Exploitation: Value of Supply, Demand, and Spatial Search for Innovation." *Organization Science* 18: 20–38.

Singh, K. 1997. "The Impact of Technological Complexity and Interfirm Cooperation on Business Survival." *Academy of Management Journal* 40: 339–376.

Stuart, T. E. 2000. "Interorganizational Alliances and the Performance of Firms: A Study of Growth and Innovation Rates in a High-Technology Industry." *Strategic Management Journal* 21: 791–811.

Stuart, T. E., and J. M. Podolny. 1996. "Local Search and the Evolution of Technological Capabilities." *Strategic Management Journal* 17: 21–38.

Teece, D. 1986. "Profiting from Technological Innovation." *Research Policy* 15: 285–305.

Teece, D. J., G. P. Pisano, and A. Shuen. 1997. "Dynamic Capabilities and Strategic Management." *Strategic Management Journal* 18: 509–533.

Tether, B. S. 2002. "Who Co-operates for Innovation, and Why: An Empirical Analysis." *Research Policy* 31: 947–967.

Torre, A., and A. Rallet. 2005. "Proximity and Localization." *Regional Studies* 39: 47–59.

Trajtenberg, M. 1990. "A Penny for Your Quotes: Patent Citations and the Value of Innovations." *RAND Journal of Economics* 21: 172–187.

Tushman, M., and L. Rosenkopf. 1992. "On the Organizational Determinants of Technological Change: Toward a Sociology of Technological Evolution." In *Research in Organizational Behavior*, edited by B. Staw, and L. Cummings, 311–347. Greenwich: JAI.

Tzabbar, D., B. S. Aharonson, and T. L. Amburgey. 2013. "When does Tapping External Sources of Knowledge Result in Knowledge Integration?" *Research Policy* 42: 481–494.

Uzzi, B. 1997. "Social Structure and Competition in Interfirm Networks: The Paradox of Embeddedness." *Administrative Science Quarterly* 42: 35–67.
Vanhaverbeke, W. 2006. "The Interorganizational Context of Open Innovation." In *Open Innovation: Researching a New Paradigm*, edited by H. Chesbrough, W. Vanhaverbeke, and J. West, 205–219. Oxford: Oxford University Press.
Weterings, A., and R. Boschma. 2009. "Does Spatial Proximity to Customers Matter for Innovative Performance? Evidence from the Dutch Software Sector." *Research Policy* 38: 746–755.
Whittington, K., J. Owen-Smith and W. W. Powell. 2009. "Networks, Propinquity, and Innovation in Knowledge-Intensive Industries." *Organization Science* 54: 90–122.
Wonglimpiyarat, J. 2005. "Does Complexity Affect the Speed of Innovation?" *Technovation* 25: 865–882.
Zaheer, A., and V. P. George. 2004. "Reach Out or Reach Within? Performance Implications of Alliances and Location in Biotechnology." *Managerial and Decision Economics* 25: 437–452.
Zander, U., and B. Kogut. 1995. "Knowledge and the Speed of the Transfer and Imitation of Organizational Capabilities: An Empirical Test." *Organization Science* 6: 76–92.