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Abstract

We refine the concept of boundary-spanning exploration, by making a distinction between explorative learning from partners and from non-partners (Partners are organizations with whom a focal firm has some kind of external venturing relations, i.e. technological alliances, corporate venturing capital, or M&As). These partners play a dual role: in explorative learning from partners, a firm teams up with external venturing partners to co-develop or transfer technology. Partners' technology base (what they know) is driving explorative learning from partners. In contrast, in explorative learning from non-partners, partners may play a role because of whom they know. That is, they inform the firm about technological opportunities beyond its corporate venturing network. The empirical analysis supports the dual role of venturing partners in facilitating the two types of explorative learning.

Keywords: exploration, external venturing, technology

1. Introduction

Firms develop new businesses and products to secure corporate growth. To reach that goal, companies increasingly use knowledge from external sources to explore new technologies (e.g., Rosenkopf and Nerkar, 2001; Lavie and Rosenkopf, 2006; Schildt et al., 2005; Keil et al., 2008). They explore new technologies beyond their existing technological capabilities (March 1991). Exploration implies learning of new knowledge that does not reside within the firm (Chesbrough, 2003; Schildt et al., 2005; Keil et al., 2008). There is convincing empirical evidence that external technology venturing, including corporate venture capital (CVC) investments (Dushnitsky and Lenox, 2005; Keil et al., 2008), alliances (Gulati, 1998), and mergers and acquisitions (M&A) (Ahuja and Katila, 2001; Puranam and Srikanth, 2007), is instrumental for technological exploration and improves innovation performance (Schildt et al.,

2005; Lavie and Rosenkopf, 2006; Lin et al., 2007).

However, corporate venturing is only a formalized source of firms' explorative learning. Innovating firms have many other means to explore new technologies beyond the corporate boundaries. For instance, firms can learn from scientific publications (McMillan et al., 2000), patent releases, contact with consultants, technology providers and intermediaries (Howells, 2006), product introductions in the market, conferences, exhibitions, benchmarking with competitors (Wiersema and Bowen, 2008; Hunt and Morgan, 1997), mobility of personnel, etc. These are just a few examples how firms can explore new technologies relying on knowledge of organizations with whom they have *no* formal venturing partnerships. Given the multiple external sources of explorative learning, we can refine the concept of boundary-spanning explorative learning which was first introduced by Rosenkopf and Nerkar (2001). We divide boundary-spanning explorative learning into two categories: companies can learn from their partners or they can learn from other companies or organizations with which they have no formalized partnerships.

Although prior studies have greatly contributed to our understanding of the relationship between external technology sourcing and exploration, they have mostly focused on firms' exploratory learning from their venturing partners. We call this 'explorative learning from partners' (ELP). In this type of exploration, innovation companies establish partnerships to tap into the technological expertise of their technology partners. In contrast, there is little insight in how external technology sourcing partnerships may also facilitate focal firms' explorative learning from other organizations with which they have no direct relationships. We call this 'explorative learning from non-partners' (ELN).

To date, the innovation management literature has shown that technology sourcing partnerships may foster the exploratory learning of innovating firms directly by bringing the latter in contact with interesting technology sources they have and informing the latter about new technological opportunities. Our empirical data indicate that the emphasis in the literature on learning from partners is not a fair representation of how firms develop explorative knowledge: only 15 percent of the explorative patents build on the knowledge of the innovating firms' direct venturing partners. To our knowledge, to date the potential dual role of external technology sourcing has not yet been investigated. The current paper aims at filling this research gap by investigate the effects of external technology venturing, including CVC, alliances, and M&As, on both types of explorative learning, i.e., ELP and ELN.

It is important to investigate the potential dual role of firms' corporate venturing on explorative learning for several reasons. First, since firms are socially embedded within various social connections in an increasingly open innovation context, non-partnering organizations could be equally important external sources for exploration as existing partners (Chesbrough, 2003, 2006). Second, a firm's external knowledge sourcing is highly relevant to its ELN because the partnerships can act for the innovating firm as radar to detect new technological opportunities. They act as a prism

(Podolny, 2001) to identify the relevance and complementarity of new technologies, and as a reputation mechanism to legitimize ELN. Finally, a firm's existing relationships might alter the incentives and constrain the resources for ELN.

This study makes several contributions to the corporate venturing and inter-organizational learning literature. First, we refine the concept of boundary-spanning explorative learning by conceptually distinguishing between ELP and ELN. Second, we empirically investigate the potentially different effects of knowledge sourcing on firms' ELP and ELN. Third, we theoretically explore and empirically test the effect of different governance modes on ELP and ELN.

The remainder of the paper is organized as follows. First, we introduce the concepts of exploration and exploitation and explain the difference between ELP and ELN. Second, we provide a theoretical background and develop hypotheses for the relationships among technology sourcing partnerships, ELP, and ELN. Next, we present the data and estimation methods to test the hypotheses. Finally, we discuss the results and draw some conclusions from our research, followed by suggestions for future research.

2. THEORY AND HYPOTHESES

2.1. The dual role of knowledge sourcing partnerships in technological exploration

Previous research has shown that firms with a strong reliance on technologies developed previously have a better innovation performance. However, they risk their technological competencies becoming less relevant as newly emerging technologies are not detected in time.

Research also shows that this internal orientation leads to the development of competency traps (Levitt and March, 1988; Levinthal and March, 1993) and core rigidities (Leonard-Barton, 1992, 1995). Firms have to acquire technological knowledge from external partners and the gains related to the internal development of technology are not sustainable unless the organization can assimilate and integrate knowledge that is developed externally (Rosenkopf and Nerkar, 2001). Exploration is usually recognized as activities that search for unfamiliar, distant and remote knowledge (Ahuja and Lampert, 2001; Benner and Tushman, 2002; Katila and Ahuja, 2002; Nerkar, 2003). Knowledge sourcing from other firms is crucial for exploration as innovations are considered the result of a recombination of component elements (Schumpeter, 1934; Henderson and Clark, 1990; Kogut and Zander, 1992). Prior studies on corporate venturing and strategic alliances have considered exploration as a learning process to integrate new technologies from a firm's venturing partners (Benner and Tushman, 2002; Schildt et al., 2005; Lavie and Rosenkopf, 2006). These technology sourcing partnerships may have different governance modes, including corporate venture capital investment, strategic alliances, joint ventures, and mergers and acquisitions (Keil et al., 2008; Van de Vrande et al., 2009).

In this paper, we focus on firms' exploration that move beyond local search and explore new technologies from other organizations. We refine the concept of boundary-spanning exploration by distinguishing two types of external sources from whom innovating firms can learn. Companies can go beyond local search by sourcing new

technology from their partners. However, they can also learn from companies or organizations with which they have no existing relations. In making the distinction between two types of external technology sources, i.e., partners and non-partners, we add an extra dimension to boundary spanning exploration which will be instrumental in explaining the dual role of external corporate venturing partners in explaining technological exploration.

Hence, we define two types of exploration, i.e., explorative learning from partners (ELP) and from non-partners (ELN) (Sorenson and Stuart, 2000; Rosenkopf and Nerkar, 2001). In ELP innovating firms learn directly from their technology sourcing relationships. That is, technology partnerships can be considered as 'pipes' through which the knowledge interactions between partners are shaped and facilitated (Podolny, 2001). A pharmaceutical company might for instance establish an R&D agreement with a biotechnology start-up to learn about the specific knowledge of the latter in a particular application of functional genomics. In this case, we expect that the new technology developed in the pharmaceutical company will be (partially) based on the technology of the start-up company. In ELN the innovating company is not learning directly from its partners. For example, a firm can learn from non-partners in different ways: scientific publications, patent releases, contact with consultants and intermediaries, product introductions in the market, conferences, exhibitions, benchmarking with competitors, and mobility of personnel, etc. are just a few examples. The literature has noticed the importance of this type of learning (Beckman et al., 2004; Lavie and Rosenkopf, 2006), but has

overlooked the role of external corporate venturing partners can play in facilitating this type of explorative learning (Schildt, et al., 2005; Keil et al. 2008).

Therefore, we argue that corporate venturing partnerships play a dual role in the boundary-spanning explorative learning of innovating firms. We know little about how a firm's venture partners may influence the exploratory learning from other organizations with whom the focal firm has no venturing relationships. In the following section, we investigate the different effects of external corporate venturing partnerships on ELP and ELN.

2.2. External venturing and exploration

Companies are increasingly using different types of cooperation mechanisms to gain technological knowledge outside their organizational boundaries. They have choices between different formal forms of external venturing partnerships. These venturing forms include corporate venture capital, non-equity alliances, equity alliances (including joint ventures), and mergers and acquisitions.

Corporate venturing investments (CVC) are usually flexible investments to get access to the knowledge of start-ups (Dushnitsky and Lenox, 2005). Investments in innovative start-ups may provide the corporation with and ensure a stake in novel technological opportunities. Non-equity alliances, including licensing, second-sourcing, distribution agreements and technology exchange agreements, refer to those technology agreements which do not involve an equity investment in the partner firm. Non-equity alliances are largely based on flexible contractual agreements. In contrast, equity alliances refer to those alliances

that require either shared ownership, independent administrative, operational and incentive system (joint ventures), or one or more partners taking an equity stake in other partners' ownership (minority holdings) (Gulati and Singh, 1998). Both non-equity and equity alliances have been found to be positively related to firms' innovation performance because they enable firms to learn from their allied partners through various levels of cooperation (Stuart, 2000; Hagedoorn and Duysters 2002). Alliances that are established in order to search for new technologies from partners usually result in positive exploratory performance (Rothaermel, 2001; Rothaermel and Deeds, 2004). Finally, merger and acquisitions (M&As) allow the acquiring firm to get access to and absorb the knowledge from the acquired firms through ownership control. Prior research also found positive relationship between M&A and innovative performance (Ahuja and Katila, 2001; Keil, et al., 2008; Vanhaverbeke et al., 2002). There is empirical evidence that external technology venturing partnerships have a direct positive effect on ELP (Schildt et al., 2005; Keil, et al., 2008; Van de Vrande et al., 2011).

There are several reasons why we believe external knowledge sourcing partnerships are also positively related to ELN. First, an innovating firm is embedded in a broader social network of firms with which it is directly or indirectly connected via its existing partnerships (Granovetter, 1985). The social embeddedness of firms provides an innovating firm not only with access to the knowledge base of its venturing partners to which it's directly connected, but also the possibility to reach out to the knowledge base of other firms which are known by or connected to the focal firm's venturing partners (Davis,

1991; Burt, 1992). External technology sourcing relationships can be viewed as channels to reach beyond the boundary of an innovating firm's direct corporate venturing networks to a larger range of firms and a broader knowledge pool (Gulati, 1998; Beckman et al., 2004; Lin et al., 2007). Second, due to their unique knowledge base, knowledge sourcing partners may help the innovating firm to identify the relevant and complementary knowledge (Burt, 1992; Nooteboom, 2000a). In other words, external technology sourcing partnerships may act as radar to detect relevant knowledge beyond a firm's network of venturing partners and they act as referrals concerning the usefulness of the new knowledge. Finally, the relationships between the innovating firm and its partners may affect third party's perceptions of the relative trustworthiness, organizational capabilities and performance of the innovating firm (Podolny, 2001). For instance, if the innovating firm has an external sourcing relationship with a firm having superior reputation and performance, other firms will perceive the innovating firm as with great capability, competence and trustworthiness (Gulati, 1995; Nooteboom, 2000b). This, in turn, raises the odds for the innovating firm to explore new technological opportunities with firms with whom it had no venturing relationships before. Therefore, we expect that firms that are rich in external technology sourcing partnerships will be more likely to undertake ELP as well as ELN than those firms with few partnerships. Accordingly, we hypothesize

Hypothesis 1a: The number of external knowledge sourcing partnerships is positively related to a firm's explorative learning from partners (ELP).

Hypothesis 1b: The number of external knowledge sourcing partnerships is positively related to a firm's explorative learning from non-partners (ELN).

Furthermore, we are also curious about whether the strength of the hypothesized effect is different for the two types of exploration. First, external partnerships provide the innovating firm with direct connections and formalized relations with its partners. Knowledge exchange in ELP is based on a certain level of reciprocity (Kachra and White, 2008) and regulated by a particular contractual agreement (Gulati, 1998). Contractual arrangements are instrumental in optimizing the technological cooperation and transfer of knowledge. However, knowledge exchange in ELN is not based on a contractual agreement. This, in turn, leads to a less structured and controlled way to assimilate and integrate knowledge from these organizations. Second, although a great number of external partners may increase the chance that novel and complementary technological knowledge will be identified and effectively utilized by the innovating firm, this might not always be the case because an innovating firm has to rely on the network resources and technological capabilities of its partners (Eisenhardt and Schoonhoven, 1996) to profit from ELN. A firm's technology sourcing partners vary in terms of their size, age, competitive position, product diversity, and financial resources (Shan, 1990; Burgers et al., 1993): their capabilities to facilitate the innovating firm to undertake ELN may differ as well. Finally, an innovating firm with many external partnerships may be conceived by other firms as competitive in many industries and markets. Thus, firms, which have no venturing

relationships with the innovating firm, may consider the former as a potential competitor and prevent their technologies from spilling over to the innovating focal firm (Schrader, 1991; Chang and Xu, 2008). In sum, we expect that the positive effect of external corporate venturing will be larger for ELP than for ELN. Accordingly, we hypothesize,

Hypothesis 1c: The positive impact of the number of external knowledge sourcing partnerships on ELP is stronger than its impact on ELN.

2.3. Governance modes of corporate venturing and exploratory learning

External knowledge sourcing partnerships differ in terms of governance modes. Firms have the choice between different levels of hierarchical control and intensity of integration. Prior research on contract choices in corporate venturing has been influenced primarily by the transaction cost theory (Gulati, 1998). The interactive nature of innovation and organizational learning requires appropriate governance to realize the potential of inter-organizational relationships and control the relational risks (Nooteboom 2004a, 2004b, Gulati et al. 2000).

The different governance modes of external technology sourcing (CVC, equity and non-equity alliances and M&As) can be ranked according to the degree of integration between the partners. Previous studies have argued that these modes of collaboration can be ranked along the continuum between arms-length transactions and a fully integrated solution (Gulati and Singh, 1998; Santoro and McGill, 2005). In line with this idea, CVCs can be considered as the type of partnership that resembles most arms-length relationships among all these governance modes. M&As, on the contrary, require a full integration

between the acquirer and acquired firm (Schildt et al., 2005; Van de Vrande et al., 2009). Alliances are positioned in the middle of the continuum. For non-equity alliances, coordination among partners is based on a contract. Members of the partners work jointly on behalf of their own organization. Equity alliances represent a somewhat more integrated form of governance because of the equity investments of the partners. In the case of joint ventures there is a separate entity created by alliance partners. It requires not only specific equity investments, but also a tight coordination between alliance partners because a separate administrative, operational and incentive system needs to be established (Gulati and Singh, 1998). Empirical evidence shows that governance modes that are appropriately aligned with the transaction requirements lead to enhanced innovation performance (Geyskens et al., 2006). As exploration usually entails high levels of uncertainty, less integrated governance modes are more likely to be the appropriate (Schilt et al., 2005; Van de Vrande et al., 2009; Gilsing and Nooteboom, 2006). However, the relationship between the integration levels of governance modes in external technology sourcing on the one hand and a firm's ELP and ELN on the other hand, has received little attention in the literature.

The existing literature has argued that higher levels of integration of governance modes of external technology sourcing are less likely to lead to explorative learning from partners because of the uncertain nature of the returns to this type of learning (compared to exploitative learning) and the uncertainty ex ante about the strategic importance and operational relatedness of the ventures (Schildt, et al., 2005). In this case,

innovating firms tend to form venturing partnerships using governance modes with low levels of commitment in order to remain flexible. In a similar vein, we argue that (low) high levels of integration in the governance modes of external corporate venturing may lead to (more) less ELN. High levels of integration in governance modes entail more specific investments in the venturing relationships. This implies that the innovating firm has less flexibility to step out of existing venturing relationships. This flexibility is also necessary in the case of ELN, because technological opportunities may change recurrently. As a result, an innovating firm can profit from loose ties, which can be easily established or dissolved when new technological opportunities emerge, with its partners. When an innovating firm is tied to its partners through highly integrated relations that are hard to reverse, it may not have the required flexibility to explore new opportunities as it is linked for a longer time to partners through strong ties (Gilsing and Nooteboom, 2006). Accordingly, we hypothesize

Hypothesis 2a: Lower levels of integration of the governance modes of external knowledge sourcing will increase a firm's performance on both ELP and ELN.

In contrast to the arguments above, the theory of transaction cost economics (TCE) argues that under high uncertainty firms prefer more integrated governance modes for their exchange relationships to control for transaction hazards and risks of spillovers (Williamson 1975, 1991). Since exploratory learning between firms is highly uncertain in terms of returns, TCE predicts that exploration from partners requires hierarchical and integrative governance modes

(Pisano, 1989). There are also reasons to expect that not only ELP but also ELN may benefit from high levels of integration in the governance modes of knowledge sourcing partnerships. Partners inform the innovating firm about opportunities beyond the current network and the question is whether the governance mode has an impact on the richness and the quality of the information. Different governance modes provide the innovating firm with different types of information about technological opportunities because partners are different and they might focus on technologies in different stages of the technology life cycle. Integrated modes also offer more fine-grained information about the opportunities compared to less integrated modes. Therefore, we argue that more integrated modes will lead to rich and adequate information between an innovating firm and its partners, which, in turn will inform the former more accurately about opportunities beyond the existing network. In this way, the innovating firm can increase its ELN. For these reasons, we formulate an alternative hypothesis:

Hypothesis 2b: Higher levels of integration of the governance modes of external knowledge sourcing will increase a firm's performance on both ELP and ELN.

3. DATA, VARIABLES AND METHOD

3.1. Data and sample

To test our hypotheses, we use a sample of 153 firms that were active in the pharmaceutical industry between 1990 and 2000. The dataset was constructed in the following way. For each year of the observation period, the largest 200 companies in the industry were collected. The pharmaceutical industry consists of mainly two types of firms: generic drug companies and innovators. To distinguish between those, the selection was based on firms' prior patents in the pharmaceutical industry. That is, the selection was based on patents filed in the following patent classes 424, 435, 436, 514, 530, 536, 800, and 930 as defined by the USPTO (Rothaermel and Hess, 2007; Rothaermel and Thursby, 2007). Large organizations are more likely to engage in external technology sourcing activities and are more likely to report them publicly (Keil et al., 2008). Prior research on alliances and acquisitions has for that reason also focused on the largest organizations in the industry (Ahuja, 2000; Gulati, 1995; Gulati and Garguilo, 1999; Hitt et al., 1997; Keil et al., 2008). After selecting the companies with patents in the relevant patent classes, research institutes and universities were removed from the sample. Next, the remaining sample was manually checked for parents and affiliates using Dun & Bradstreet's Who Owns Whom, which were then aggregated on the parent company level. After checking for duplicates, this leads to 153 independent firms in the sample, which will be referred to as 'focal firms' to distinguish them from their partners.

Next, we have gathered for these firms all the CVC investments, technology alliances, minority holdings, joint ventures, and merger and acquisition activities during the period of 1985-2000, which allows us to calculate some of the independent variables using a five-year time lag. Furthermore, we collected patent data and financial information. Corporate venture capital data was derived from the Thomson VentureXpert database. Data concerning alliances and joint ventures was obtained from the MERIT-CATI databank on Cooperative

Agreements and Technology Indicators (Hagedoorn, 1993). We used Thomson ONE Banker to collect information regarding the companies' M&A activity. Both the collected alliances and corporate venture capital investments have a strong technology component, therefore, to make a consistent sample selection for all types of governance modes, we only included technological M&As in our sample, adapting the method by Ahuja and Katila (2001).

Patent information was collected for all firms included in our sample using data from the US Patent and Trademark Office. Because the US Patent and Trademark Office grants patents both on subsidiary and on parent company level (Patel and Pavitt, 1997), and the organizational level on which patents are applied for differs between companies, we consolidated the patents on parent company level for each observation year, using Who Owns Whom by Dun & Bradstreet. In addition to that, we gathered financial data using Worldscope, including sales, research and development expenses and the number of employees.

3.2. Variables

Dependent variables

We make a distinction between two types of dependent variables: explorative learning from partners (ELP) and explorative learning from non-partners (ELN). We refer to Figure 1 to explain the distinction between both variables in detail. This figure illustrates how we categorize different types of learning by tracking the backward citations of new patents of an innovating firm in a particular year. When companies build on prior technological knowledge, new patents must cite existing patents on which it builds. As a result, patent

citations provide us with a unique and reliable instrument to define different types of exploration. This taxonomy is based on the assumption that when firms innovate, they usually build on existing technologies developed by their own or by other organizations (Nelson and Winter, 1982; Katila, 2002).
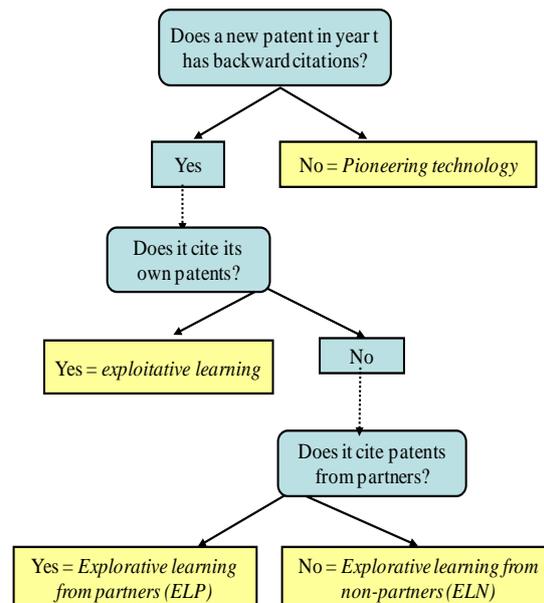
Figure 1. How to distinguish between ELP and ELN

Next, we can distinguish between two different situations when a new patent cites prior patents. On the one hand, a new patent can cite some of the assignee's own patents. This implies that the new patent builds on the firm's prior technical expertise and, as a result, the patent will have one or more self-citations. This type of patents is characterized as exploitative learning (Benner and Tushman, 2002; Rosenkopf and Nerkar, 2001; Schildt et al., 2005). In other cases a firm can successfully file new patents that do not cite any of its own prior art. When an innovating firm's new patents have no backward self-citations, the firm explores new technological areas and broadens its technological capabilities by building on the knowledge from other

organizations. Patents with no self-citations but citing patents from other firms are considered to be more explorative than those that also cite own prior technology. These patents are important to avoid potential problems related to local search (March and Simon, 1958; Nelson and Winter, 1982; Helfat, 1994).

So far, we have only been summarizing some of the existing definitions of technological exploitation and exploration. This study contributes to the literature by further segmenting the exploratory patents into two subcategories. On the one hand, a patent is categorized as an ELP-patent when there are no self-citations and when some backward citations refer to those organizations that have established one or more venturing relationships with the innovating firm during the 5 years prior to the observation year (Benner and Tushman, 2002; Schildt, et al., 2005). On the other hand, a patent is categorized as an ELN-patent when there are no self-citations and when there are only backward citations referring to organizations with whom the innovating firm had no formal relationships during the last 5 years. More specifically, we counted for in every observation year the number of times each technology-sourcing mode was established in the five years prior to the observation year (t-1 to t-5). This moving window approach is considered to be an appropriate timeframe during which the existing portfolio of external technology activities is likely to have an influence on the current technological performance of a firm (Kogut, 1988, 1989; Gulati, 1995).

Both dependent variables are count variables. ELP is calculated as the sum of patents successfully applied for per year by the focal firm, which have at least one citation to its partner's

prior patents, but no citations to its own prior patents. ELN is calculated as the number of patents successfully applied for per year by the focal firm which neither cites its own prior patents nor its partners' prior patents. In our sample, there are 171,532 patents in total, of which 101,228 can be categorized as exploitative patents and 70,304 as exploratory patents; 15 percent of the exploratory patents cite partners' prior patents (ELP).

Independent variables

Hypotheses 1a, 1b, 1c, 2a and 2b predict a direct positive effect of CVC investments, non-equity alliances, equity alliances, M&As on ELP as well as on ELN. Therefore, for every observation year t, we counted the number of CVC investments, non-equity alliances, equity alliances and M&As respectively in the five years prior to the observation year (t-1 to t-5). We took a five-year moving window in line with the arguments developed above. This variables measure the effect of corporate venturing on the two types of explorative learning.

Control variables

Firm size: Firms of different sizes innovate differently. Large firms usually have more external corporate venturing partnerships and are more centrally positioned in their venturing networks than small firms. They also have greater capacity to cooperate in multiple tasks, which is crucial for inter-organizational learning and absorptive capacity (e.g., Shan, 1990; Powell and Brantley, 1992). Large firms are found to undertake exploitative and exploratory learning at the same time whereas small firms can maximize innovative performance by adopting a focused approach on exploitation or exploration (Beckman et al. 2004, Stuart 2000; Lin et al.,

2007). Approaching exploration in a different way, Almeida and Kogut (1997) suggest that smaller firms explore new technological opportunities that are ignored by larger ones. Small companies may be more likely to explore new technological areas with focused strategy in less crowded areas (Lin et al., 2007; Almeida and Kogut, 1997). Since explorative learning from non-partners involves higher levels of uncertainty because the learning process is not embedded in formal partnerships, we can argue in line with Almeida and Kogut (1997) that small firms will be relatively more inclined to explore from non-partners than from partners. We measure firm size as the natural logarithm of sales of the innovating firms.

R&D intensity: Prior research has indicated a strong relationship between R&D inputs and innovation, and regarded R&D expenditures as a means to maintain absorptive capacity necessary to benefit from external technology sourcing (Cohen and Levinthal, 1990). Consequently, we include R&D expenditures as a percentage of sales as a control variable. The control variables size and R&D intensity are lagged by one year.

Technological distance: Another important factor to control for is the technological distance between the focal firm and its venturing partners (Ahuja and Lampert, 2001; Nerkar and Roberts, 2004; Phene et al., 2006; Nooteboom et al. 2007). Technological distance refers to the (lack of) overlap between the knowledge base of the focal company and the knowledge base of the partnering firms. We use the method developed by Jaffe (1986) to calculate the technological proximity between two firms (i and j). Following this method, the technological proximity between two firms is computed as the uncentered correlation between their respective vectors of technological capital (measured as the cumulative patent applications in technology class k over the five years prior to the investment), P_{ik} and P_{jk} respectively:

$$T_{ij} = \frac{\sum_k P_{ik} P_{jk}}{\sqrt{\sum_k P_{ik}^2 \sum_k P_{jk}^2}}$$

The technological proximity (T_{ij}) measure takes a value between 0 and 1 according to their common technological interests. To calculate technological distance, this variable is transformed into a new one, which equals $1 - T_{ij}$.

Technological age: Technological age is another firm-level control variable. To measure it, we first measure the technological newness of a firm's patent portfolio. Technological newness is operationalized in two steps (Van de Vrande et al., 2009). First, we determine the "age of all patent classes". This is calculated as the median of the age of all patents in a patent class in a particular year. The age of the patent is the time elapsed between the application year and the year of observation. To overcome outlier bias, we use the median age rather than the average to calculate the age. Second, to calculate the average technological age of a firm, we multiply the share of patent applications by the technology age for each patent class. We control for the technological age of firms for the following reason: If a firm has a relevantly young portfolio of patents, it holds some technologies that are in the early phase of the life cycle. These technologies usually entail high technological uncertainty but also ample opportunities for technological exploration. As a result, we expect that technological age will be negatively related to both types of technological learning.

We also included several types of dummy variables. Focal firms are companies that are based in America, Europe, or Asia. Companies on different continents may have a different attitude towards explorative research due to the differences in their cultural and institutional background. Consequently, we introduce two dummy variables to control for the geographic location of the focal firms (firms based in America are set as default). We also introduced a dummy variable to control for industries. Because the sample consists of firms in both pharmaceutical and chemical industries, we use a dummy variable to control for differences in explorative research between the two industries. Finally, we included dummy variables to control for the unobserved effects of time in each consecutive year.

3.3. Method

The dependent variables, explorative learning from partners and non-partners, are count variables. A Poisson regression approach provides a natural baseline model for such data (Hausman et al., 1984; Henderson and Cockburn, 1996; Long and Freese, 2003). However, Poisson regressions assume that the mean and variance of the event count are equal. This assumption is likely to be violated since overdispersion usually occurs in patents. Because our data shows significant evidence of overdispersion (i.e. the variance exceeds the mean), a negative binomial regression model is more appropriate (Cameron and Trivedi, 1998). The negative binomial model for panel data is estimated using the XTNBREG command in STATA.

To determine whether a random- or fixed-effects model is more appropriate approach for the analysis, we further conducted a Hausman specification test (1978) upon the baseline model. The Hausman test was not significant, indicating that it is appropriate to use a random-effects model as an alternative for the fixed-effects model. Since random-effects model do not control for time-invariant variables (i.e., variables that differ between cases but remain constant over time), we include dummy variables to control for unobserved effects of industry and geographic regions.

4. RESULTS

The descriptive statistics and correlations between the variables for the 898 firm-year observations in the sample are presented in Table 1. The correlation between equity alliances and non-equity alliances is high (with a coefficient of 0.7145), which may cause multicollinearity problems. For this reason, we did not run the full model including all the different governance modes along with the control variables. Instead, we ran several models that include only one single governance mode in order to examine the effects of each type of governance mode on the two types of explorative learning separately. Next, we estimated two proxies of the full model. The first one includes CVC, equity alliances and M&As, and the second one model contains CVC, non-equity alliances and M&As, besides the control variables (see Table 1 and Table 2). In this way, equity alliance and non-equity alliances are not included simultaneously in a single model.

Insert Tables 1 and 2 here

Table 2 presents the results of the regression analysis using random-effects negative binomial estimations of the two types of exploration. The dependent variable in Models 1 to 7 is ELP. The results for ELN are represented in Models 8 to 14.

The baseline models (respectively, Models 1 and 8) include the linear effects of the control variables. Hypotheses 1a and 1b predict that the number of external sourcing relationships, including CVC, non-equity alliances, equity alliances, and M&A, are positively associated with both types of explorative learning. In Table 2, Models 2 to 5 show that all types of external governance modes are positively related to ELP (the coefficients are significant at various levels). Models 9 through 12 reveal that most types of external governance modes have a positive effect on ELN. The exception is equity alliances (Model 10). As a result, we found strong support for Hypotheses 1a and 1b (except for the effect of equity alliances on ELN). These findings support our claim that innovation partners play a dual role in technological exploration.

Hypothesis 1c predicts that the positive effect of the number of knowledge sourcing relations on ELP is stronger than the effect on ELN. We find that the coefficients of each governance mode in the models explaining ELP are larger than the corresponding ones in the models for ELN. Hence, we find empirical support for Hypothesis 1c. This finding implies that the positive effect of external venturing partnerships on explorative learning from partners is stronger compared to the learning from non-partners. The stronger effect on ELP can be explained through the contractual arrangements and the management of the formal agreement(s) between the partners.

Hypotheses 2a and 2b predict the relationship between levels of integration in the governance modes of external knowledge sourcing and explorative learning with partners and non-partners from two seemingly conflicting perspectives. To test these two hypotheses, we included different types of governance modes into the semi-full models of Table 2. In Models 6 (for ELP) and 13 (for ELN), CVCs, equity alliances and M&As are included. Alternatively, in Model 7 (for ELP) and 14 (for ELN), we inserted CVCs, non-equity alliances and M&As. The results in Models 6 and 7 indicate that more integrated governance modes have a stronger positive impact on ELP. The results in Models 13 and 14 also confirm that more integrated governance modes have a stronger positive effect on ELN (except for equity alliances in Model 13). However, the effect is not as pronounced as the results in Model 7 for ELP. In sum, we can conclude that M&As have a stronger effect on both types of explorative learning than alliances, and alliances are in turn more appropriate for ELP and ELN than CVC. In other words, we find support for the traditional governance perspective, i.e., Hypothesis 2b, which argues that the risky and uncertain nature of exploration requires more integrated governance modes. Innovating firms need some specific investment to develop mutual understanding, to cross-cognitive distance (Nooteboom, 1999).

Finally, it is also interesting to have a look at the results of several control variables in Table 2. Firm size has a positive and significant effect in all models for ELP as well as for ELN. Recall that firm size is measured as the natural logarithm of sales so that the coefficient in a negative binomial regression model can be considered as elasticity. The fact that the coefficients of firm size consistently are positive but less than one implies that smaller firms are relatively more innovative than larger firms in both types of explorative search. Next, the coefficients of R&D intensity are positive and significant in all models for both

types of explorative learning (except for Model 7), which suggests that R&D investments facilitate firms' explorative search. However, R&D intensity has a substantially larger effect on ELP compared to ELN. The stronger relation between R&D investments and ELP is not surprising: When firms establish technology partnerships, explorative learning from the partners will increase more when the partnering firms are investing more in their collaborative innovation efforts. In the case of ELN, more R&D investments do not necessarily facilitate learning from companies that are not partners of the focal company. If firms invest for instance more in their scouting of new technologies they may find relevant innovations and ideas that can foster ELN. However, the relationship between R&D investments and ELN will be much weaker compared to the case where a company spends more on R&D as a result of new knowledge sourcing relations with its innovation partners.

5. DISCUSSION AND CONCLUSION

This study investigates the dual role of external technology sourcing, including corporate venture capital (CVC), alliances and mergers and acquisitions (M&A), on two different types of exploratory learning – exploration from partners (ELP) and exploration from non-partners (ELN). They represent two different types of innovation strategies that tackle the problem of local search in a different way. The empirical results of this study provide support for the idea that external partners not only give the focal firm access to their technological capabilities, but they are also instrumental in the focal firm's search to explore new technologies beyond its current network of partners. In the first case (ELP), the expertise of

the partners determines the outcome of the focal firm's explorative learning. In the second case (ELN), it is the reputation of the firm's partners and the information gained through who they know, that leads to more explorative learning. This confirms the dual role of corporate venturing partnerships.

Next, we found that the positive effect of venturing partnerships on ELN is less pronounced than on ELP. This outcome is not surprising since ELP is based on direct information flows between the firm and its partners: they can structure the governance of their relationship to maximize the explorative learning. Partners help the focal firms also to explore from organizations that are not part of the venturing partner network. The risks associated with this type of learning cannot be directly controlled by the governance mechanisms and management of venturing partnerships. We also found that the risky and uncertain nature of explorative learning requires highly integrated governance modes. Finally, increasing technological distance between the focal innovating firm and its corporate venturing partners from a low to moderate level enhances ELP, while an increase from a moderate to a high level will hamper it. Our findings also suggest that the increase of technological distance between the focal innovating firm and its venturing partners is associated with a decrease in ELN. This implies that technological proximity with venturing partners is important to improve ELN.

Next, we would like to point at some broader implications of our research and to lay out some directions for future research about organizational boundary spanning exploration.

First, we did not examine whether there are complementarities or tradeoffs between the two types of explorative learning. Tradeoffs might be induced by budget restrictions and inertia through path dependent learning. The two types of explorative learning may be complementary because management might eventually benefit from strategically balancing different types of exploration. From a resource-based view, resource allocation is a strategic choice when available resources in a firm are limited. Resource allocation requires budgeting, which inevitably involves rankings of alternatives. Some projects are deemed more important than others and are awarded a larger share of available funds and management attention (Simons, 2006). Suppose a firm intends to enhance innovative performance by exploring new technology opportunities from external sources, top management might downplay learning from non-partners in favor of exploration from venturing partners because of budget restrictions. Tradeoffs may be also induced through organizational inertia. The outcome of a prior strategic action will reinforce and shape new choices according to the organizational learning literature (Levitt and March, 1988). Choices that lead to positive outcomes are reinforced, while the choices that lead to negative outcome will be avoided. Due to this path dependence in decision making, we propose that firms that gain positive experience in explorative learning from partners will continue to invest in this type of learning and pay less attention to learning from non-partners. Finally, the two types of exploration may be complements: Firms have to balance exploitation and exploration (March, 1991; Lin et al. 2007), but they may also benefit from balancing two

types of exploration. Their focus and objectives are different and they jointly leverage external relationships, increasing in this way the effectiveness of the innovation process.

Other opportunities may be related to the operationalization of the two types of exploration. We have been using both concepts in an exclusive way. A patent that cites prior patents of partners is categorized as learning from partners, irrespective of the number of citations to non-partners. The analysis can be improved by developing more sophisticated, continuous variables that range between 100% partner citations and 100% non-partner citations. Our current study on exploration can also be easily extended to exploration to both organizational and technological boundary spanning (Rosenkopf and Nerkar, 2003). We only focused on exploration as an organizational boundary spanning activity. Including technological boundary-spanning adds complexity and will certainly enrich the analysis.

Finally, extending the types of relationships between partners (e.g. licensing, arm's length R&D-contracting, patent search, informal / personal contacts, etc.) may of course also help to get a more accurate picture how external sources of knowledge enhance firms' explorative learning. In a similar vein, one can introduce partners' partners and check whether the "non-partners" are indirectly linked to the focal firm or not. As shown in the alliance literature (Ahuja, 2000; Hagedoorn; Letterie and Palm, 2011), a firm's partners' partners may also be an important source of external knowledge

This study also has several managerial implications. First, managers who encourage explorative learning should establish external

knowledge sourcing relations for two reasons. Partners can be interesting because of their technology base, but they are also helpful in finding technology sources beyond its partner network. Managers should take into account that by establishing relations with technology partners, they will not only have access to the technology of these partners, but they also will be informed about technologies, business opportunities, and organizations, which can extend the firm's explorative learning beyond the point of what can be learned directly from the partners' technological knowledge. We hope that our investigation of the dual role of partners' explorative learning may provide new insights for inter-organizational learning in general and for technological exploration in particular.

References

Ahuja, G. (2000). Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study. *Administrative Science Quarterly,* 45(3), 425-455

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

Ahuja, G. & Katila, R. (2001). Technological acquisition and the innovation performance of acquiring firms: A longitudinal study. *Strategic Management Journal*, 22, 197-220.

Almeida, P. (1996). Knowledge sourcing by foreign multinationals: Patent citation analysis in the U.S. semiconductor industry. *Strategic Management Journal*, 17, 155-165.

Almeida, P. & Kogut, B. (1997). The Exploration of Technological Diversity and the Geographic Localization of Innovation. *Small Business Economics*, 9, 21-31.

Beckman, C. M. & Haunschild, P. R. (2002). Network Learning: The Effects of Partners' Heterogeneity of Experience on Corporate Acquisitions. *Administrative Science Quarterly*, 42(1), 92-124.

Beckman & Philips, D. J. (2004). Friends or strangers? Firm-specific uncertainty, market uncertainty, and network partner selection. *Organization Science*, 15, 259-275.

Benner, M. J. & Tushman, M. L. (2002). Process management and technological innovation: A longitudinal study of the photography and paint industries. *Administrative Science Quarterly,* 47, 676-706.

Burgers, W. P., C. W. L. Hill & W. C. Kim (1993). A theory of global strategic alliances: The case of the global auto industry. *Strategic Management Journal,* 14(6), 419–432.

Burt, R. S. (1992). *Structure Holes: The Social Structure of Competition*. Harvard University Press, Cambridge, MA.

Cameron, A. C. And Trivedi, P. K. (1998). *Regression Analysis of Count Data*. Econometric Society Monograph No.30, Cambrigde University Press.

Chang, S. J. and Xu, D. (2008). Spillovers and competition among foreign and local firms in China. *Strategic Management Journal*, 29, 495-518.

Chesbrough, H.W. (2003). *Open Innovation: The*

New Imperative for Creating and Profiting from Technology. Harvard Business School Press, Boston: MA.

Chesbrough, H.W. (2006). *Open innovation Business Models; How to thrive in the new innovation landscape.* Harvard Business School Press, Boston: MA.

Cohen, M. D. & Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly,* 35, 128-152.

Davis, G. F. (1991). Agents without principles? The spread of the poison pill through the intercorporate network. *Administrative science Quarterly*, 36, 583-613.

Dushnitsky, G. & Lenox, M.J. (2005). When do incumbents learn from entrepreneurial ventures? Corporate venture capital and investing firm innovation rates. *Research Policy*, 34, 615-639.

Eisenhardt, K. & C. B. Schoonhoven (1996). Resource-based view of strategic alliance formation: Strategic and social effects in entrepreneurial firms, *Organization Science,* **7**(2), 136–150.

Geyskens, I., Steenkamp J.E.M. & Kumar N. (2006). Make, buy, or ally: A transaction cost theory meta-analysis. *Academy of Management Journal*, 49(3), 519–543.

Gilsing, V. A. & Duysters, G. M. (2008). Understanding novelty creation in exploration networks—structural and relational embeddedness jointly considered. *Technovation*, 28, 693-708.

Gilsing, V. A. & Nooteboom, B. (2006). Exploration and exploitation in innovation systems: The case of

pharmaceutical biotechnology. *Research Policy*, 35(1), 1-23.

Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology*, 91(3), 481-510.

Gulati, R. (1995). Social Structure and Alliance Formation Patterns: A longitudinal Analysis. *Administrative Science Quarterly*. 40:619-652.

Gulati. R. (1998). Alliances and networks. *Strategic Management Journal*, 19(4), 293-317.

Gulati, R. & Singh, H. (1998). The architecture of cooperation: Managing coordination costs and appropriation concerns in strategic alliances. *Administrative Science Quarterly,* 4, 781-814.

Gulati, R. and Garguilo, M. (1999). Where do interorganizational networks come from? *American Journal of Sociology*, 104, 1439-1493.

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic networks. *Strategic Management Journal*. 21, 203-215.

Hagedoorn, J. (1993). Understanding the rationale of strategic technology partnering inter-organizational modes of cooperation and sectoral difference. *Strategic Management Journal*, 14, 371-385.

Hagedoorn, J. & Duysters, G. (2002). Learning in dynamic inter-firm networks: The efficacy of multiple contacts. *Organization Studies,* 23(4), 525-548.

Hagedoorn, J., Letterie, W. & Palm F. (2011), The information of R&D alliances: The preference for local or distant ties.

Strategic Organization, 9(4), 283-309.

Hausman, J. (1978). Specification tests in econometrics. *Econometrica*, 46: 1251–71.

Hausman J., Hall, B. & Griliches, Z. (1984). Econometric models for count data with an application to the patents-R&D relationship. *Econometrica,* 52, 909-938.

Helfat C.E. (1994). Evolutionary trajectories in petroleum firm R&D. *Management Science,* 40(12), 1720–1747.

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

Henderson, R. M. & Cockburn, I. (1996). Scale, Scope and Spillovers: The Determinants of Research Productivity in the Pharmaceutical Industry. *Rand Journal of Economics,* 26, 32-59.

Hitt, M. A., Hoskisson, R. E. & H. Kim (1997). International diversification: Effects on innovation and firm performance in product-diversified firms. *Academy of Management Journal*, 40(4), 767-798.

Howells, J. (2006). Intermediation and the role of intermediaries in innovation. *Research Policy*, 35(5), 715-728.

Hunt, S. D. & R. M. Morgan. (1997). Resource advantage theory: a general theory of competition? *Journal of Marketing*, 61(3), 74-82.

Ibarra, H. (1993). Network centrality, power, and innovation involvement: Determinants of technical and administrative roles. *Academy of Management Journal*, 36, 471-501.

Jaffe, A. B. (1986). Technological opportunity and spillovers of R&D: Evidence from firms' patents, profits and market value. *American Economic Review*, 76, 984-1001.

Kachra, A. & White, R.E. (2008). Know-how transfer: The role of social, economic/competitive, and firm boundary factors. *Strategic Management Journal*, 2, 425-445.

Katila, R. (2002). New product search over time: Past ideas in their prime? *Academy of Management Journal*, 45(5), 995-1010.

Katila, R. & Ahuja, G. (2002). Something old, something new: A longitudinal study of search behavior and new product introduction. *Academy of Management Journal,* 45(6), 1183-1194.

Keil, T., M. Maula, H. Schildt, & S.A. Zahra (2008). The effect of governance modes and relatedness of external business development activities on innovation performance. *Strategic Management Journal*, 29(8), 895–907.

Kogut B. 1988. A study of the life cycle of joint ventures. In: Contractor, F., Lorange, P. (Eds.), *Cooperative Strategies in International Business*. Lexington Books, Lexington, MA, pp. 169–186.

Kogut B. 1989. The stability of joint ventures: reciprocity and competitive rivalry. *Journal of Industrial Economics,* 38, 183–198.

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

Lavie, D. & Rosenkopf, L. (2006). Balancing

Exploration and Exploitation Alliance Formation. *Academy of Management Journal,* 49(4), 797-818.

Leonard-Barton D. (1992). Core capabilities and core rigidities: a paradox in managing new product development. *Strategic Management Journal*, Summer Special Issue 13, 111–126.

Leonard-Barton D. (1995). *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*. Harvard Business School Press: Boston, MA.

Levinthal D.A. & March JG. (1993). The myopia of learning. *Strategic Management Journal*, Winter Special Issue 14, 95–112.

Levitt, B. & March, J. M. (1988). Organizational Learning, *Annual Review of Sociology*, 14, 319-338.

Lin, Z., Yang, H. B. & Demirkan, I. (2007). The performance consequences of ambidexterity in strategic alliance formations: Empirical investigation and computational theorizing. *Management Science*, 53 (10), 1645-1658.

Long, J. S. & Freese, J. (2003). *Regression Models for Categorical Dependent Variables Using Stata.* Stata Press. College Station, TX.

March, J.G. (1991). Exploration and exploitation in organizational learning. *Organization Science,* 2(1), 71-87.

March J.G. & Simon H. (1958). *Organizations*. Wiley: New York.

McMillan, G. S., Narin, F. & Deeds, D. L. (2000). An analysis of the critical role of public science in innovation: the case of biotechnology. *Research Policy*, 29(1),1-8.

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

Nerkar, A. (2003). Old is gold? The value of temporal exploration in the creation of new knowledge. *Management Science*, 49(2), 211-229.

Nerkar, A. & Roberts, P. W. (2004). Technological and product-market experience and the success of new product introductions in the pharmaceutical industry. *Strategic Management Journal*, 25, 779-799.

Nooteboom, B. (1999). *Inter-Firm Alliances: Analysis and Design.* Routledge, London.

Nooteboom, B. (2000a). *Learning and Innovation in Organizations and Economies.* New York: Oxford University Press.

Nooteboom, B. (2000b). Institutions and Forms of Co-ordination in Innovation Systems. *Organization Studies*, 21(5), 915-939.

Nooteboom, B. (2002). *Trust: forms, foundations, functions, failures and figures*, Edgar Elgar: Cheltenham   UK.

Nooteboom, B. (2004a). Competence and governance: How can they be combined? *Cambridge Journal of Economics*, Vol. 28 (4): pp. 505-526.

Nooteboom, B. (2004b). *Interfirm Collaboration, Learning and Networks: An Integrated Approach.* London: Routledge.

Nooteboom, B., Vanhaverbeke, W., Gilsing, V., Duysters, G. & Van den Oord, A. (2007). Optimal cognitive distance and absorptive capacity, *Research Policy*, 36, 1016–1034.

Patel, P. & Pavitt, K. (1997). The techonological competencies of the world's largest firms:

Complex and path-dependent, but not much variety. *Research Policy*, 26:141-156.

Phene, A., Fladmoe-Lindquist, K. & Marsh, L. (2006). Breakthrough innovations in the U.S. biotechnology industry: the effects of technological space and geographic origin. *Strategic Management Journal*, 27 (4), 369-388.

Pisano, G. (1989) The R&D boundaries of the firm: an empirical analysis. *Administrative Science Quarterly*, 35(1), 109–126.

Podolny, J. M. . (2001) Networks as the Pipes and Prisms of the Market. *American Journal of Sociology*, 107(1), 33-60.

Powell, W. W. & Brantley, P. (1992). Competitive Cooperation in Biotechnology: Learning through Networks. In N. Nohria and R. G. Eccles (Eds.), *Networks and Organization*, Cambridge, MA: Harvard Business School Press.

Puranam, P. & Srikanth, K. (2007). What they know vs. what they do: how acquirers leverage technology acquisitions. *Strategic Management Journal*, 28, 805–825.

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

Rothaermel, F. (2001). Incumbent's advantage through exploiting complementary assets via interfirm cooperation. *Strategic Management Journal*, 22, 687-699.

Rothaermel, F. T. & Deeds, D. L. (2004). Exploration and Exploitation Alliances in Biotechnology: A System of New Product Development. *Strategic Management Journal*, 25(3), 201-222.

Rothaermel, F. & Hess A. M. (2007). Building Dynamic Capabilities: Innovation Driven by Individual-, Firm-, and Network-Level Effects. *Organization Science*, 18(6), 898-921.

Rothaermel, F. & Thursby M. (2007). The nanotech versus the biotech revolution: Sources of productivity in incumbent firm research. *Research Policy,* 36(6), 832-849.

Santoro, M.D. & McGill, J.P. (2005). The Effect of Uncertainty and Asset Co-specialization on Governance in Biotechnology Alliances. *Strategic Management Journal*, 26, 1261-1269.

Schildt, H.A., Maula, M.V.J. & Keil, T. (2005). Explorative and exploitative learning from external corporate ventures. *Entrepreneurship Theory and Practice*, 29(4), 493-515.

Schrader, S. (1991). Informal technology transfer between firms: Cooperation through information trading. *Research Policy*, 20,153-170.

Schumpeter, J. (1934). *The theory of economic development*. Cambridge, MA: Harvard University Press.

Shan, W. (1990). An Empirical Analysis of Organizational Strategies by Entrepreneurial High-technology Firms. *Strategic Management Journal*, 11, 129-139.

Simons, J. (2006). Big Pharma's New R and D Center: The Trash Bin. *Fortune*, (European edt.) 154(12), 28

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

Stuart, T. E. (2000). Interorganizational alliances and the performance of firms: A study of growth and innovation rates in high-technology industry. *Strategic Management Journal*, 21, 791-811.

Van de Vrande, V., Vanhaverbeke, W., & Duysters, G. (2009), External Technology Sourcing: The Effect of Uncertainty on Governance Mode Choice. *Journal of Business Venturing,* 24(1), 62-80.

Van de Vrande, V., Vanhaverbeke, W. & Duysters, G. (2011); Additivity and Complementarity in External Technology Sourcing: The Added Value of Corporate Venture Capital Investments? *IEEE-TEM*, 58(3), 483-496.

Van de Vrande, V., Vanhaverbeke, W. & Duysters, G. (2011). Technology in-sourcing and the Creation of Pioneering Technologies, *Journal of Product Innovation Management*, 28, 974-987.

Vanhaverbeke, W., Duysters, G., Noorderhaven, N., (2002). External Technology Sourcing Through Alliances or Acquisitions: An Analysis of the Application-Specific Integrated Circuits Industry. *Organization Science,* 13(6), 714-733.

Wiersema, M. F. & H. P. Bowen (2008). Corporate diversification: the impact of foreign competition, industry globalization, and product diversification. *Strategic Management Journal*, 29(2), 115-132.

Williamson, O.E. (1975). *Markets and Hierarchies: Analysis and Anti-trust Implications.* New York: The Free Press, NY.

Williamson, O.E. (1985). *The Economic Institutions of Capitalism: Firms, Markets and Relational Contracting.* Free Press, New York, NY

Williamson, O.E. (1991). Strategizing, economizing, and economic organization. *Strategic Management Journal,* 12,75-94.

Williamson, O.E. (1996). Economic organization: The case for candor. *Academy Management Review*, 21(1), 48-57.

Table 1. Descriptive statistics and Correlations

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. ELP	1												
2. ELN	0.5205	1											
3. Firm size	0.2851	0.2685	1										
4. R&D intensity	-0.0421	-0.0968	-0.3448	1									
5. Technological age	0.0207	0.0384	0.0233	-0.2443	1								
6. Dummy Europe	0.0238	0.1909	-0.1737	0.0082	0.1648	1							
7. Dummy Japan	0.1128	-0.0583	0.7589	-0.0456	-0.1615	-0.3356	1						
8. Dummy Industry	-0.2035	-0.1776	-0.0311	0.2820	-0.4182	0.1153	0.1423	1					
9. Tech. distance	-0.0657	0.1216	-0.1090	-0.1061	0.2131	0.0614	-0.1884	-0.1906	1				
10. CVC	0.1085	0.1739	-0.0191	-0.0080	-0.0778	-0.0538	-0.1319	-0.0584	0.0785	1			
11. Non-equity alliances	0.6676	0.4754	0.1231	-0.0414	0.0138	0.1095	-0.1131	-0.1548	-0.0007	0.2749	1		
12. Equity alliances	0.6511	0.4858	0.1854	-0.0643	0.0403	0.0409	-0.0599	-0.2120	0.0059	0.2925	0.7145	1	
13. M&As	0.2148	0.3625	0.0107	-0.1404	0.2029	0.1915	-0.3121	-0.2259	0.1615	0.3739	0.3574	0.3650	1
Mean	11.8207	57.2861	9.7471	0.1738	10.2763	0.2984	0.2093	0.4788	0.7159	0.7438	6.6748	2.8596	2.9365
s.d.	51.5243	67.2342	2.1310	0.1738	1.9784	0.4578	0.4070	0.4998	0.1882	2.8199	12.8809	4.9199	3.7388

Table 2: Random-effects negative binomial estimations for ELP and ELN (with the linear effects of control variables in the baseline model)

Models	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	ELP	ELP	ELP	ELP	ELP	ELP	ELP	ELN	ELN	ELN	ELN	ELN	ELN	ELN
Size	0.596	0.576	0.554	0.503	0.495	0.411	0.375	0.408	0.403	0.422	0.401	0.384	0.388	0.371
	(0.101)***	(0.101)***	(0.100)***	(0.103)***	(0.104)***	(0.103)***	(0.102)***	(0.040)***	(0.040)***	(0.042)***	(0.041)***	(0.040)***	(0.043)***	(0.041)***
R&D	1.522	1.517	1.348	1.227	1.328	1.031	0.984	0.744	0.738	0.79	0.729	0.69	0.713	0.668
	(0.623)**	(0.628)**	(0.613)**	(0.615)**	(0.625)**	(0.612)*	(0.604)	(0.229)***	(0.229)***	(0.232)***	(0.230)***	(0.226)***	(0.231)***	(0.227)***
Europe	0.222	0.267	0.139	0.275	0.214	0.061	0.175	0.077	0.099	0.081	0.062	0.025	0.053	-0.009
	(0.242)	(0.244)	(0.237)	(0.234)	(0.238)	(0.235)	(0.229)	(0.132)	(0.133)	(0.132)	(0.131)	(0.131)	(0.133)	(0.133)
Japan	3.878	-3.728	-3.686	-3.579	-3.263	-2.905	-2.884	-1.764	-1.726	-1.813	-1.703	-1.706	-1.703	-1.608
	(0.569)***	(0.573)***	(0.561)***	(0.559)***	(0.589)***	(0.573)***	(0.559)***	(0.248)***	(0.249)***	(0.252)***	(0.248)***	(0.246)***	(0.251)***	(0.246)***
Pharma. Ind.	-1.428	-1.402	-1.307	-1.284	-1.454	-1.272	-1.275	-0.143	-0.143	-0.166	-0.111	-0.112	-0.127	-0.072
	(0.228)***	(0.229)***	(0.231)***	(0.227)***	(0.229)***	(0.229)***	(0.224)***	(0.123)	(0.123)	(0.124)	(0.124)	(0.123)	(0.124)	(0.123)
Tech. age	-0.077	-0.06	-0.075	-0.054	-0.069	-0.062	-0.038	-0.031	-0.028	-0.031	-0.025	-0.033	-0.03	-0.025
	(0.043)*	(0.044)	(0.043)*	(0.043)	(0.043)	(0.044)	(0.045)	(0.013)**	(0.013)**	(0.013)**	(0.013)*	(0.013)**	(0.013)**	(0.013)*
Tech. distance	-1.372	-1.422	-1.07	-1.001	-1.739	-1.351	-1.364	-0.225	-0.232	-0.245	-0.203	-0.275	-0.285	-0.256
	(0.423)***	(0.423)***	(0.448)**	(0.443)**	(0.439)***	(0.456)***	(0.457)***	(0.118)*	(0.117)**	(0.118)**	(0.119)*	(0.119)**	(0.119)**	(0.120)**
CVC		0.017				0.001	-0.01		0.008				0.006	0.001
		(0.009)*				(0.009)	(0.009)		(0.004)**				(0.004)	(0.004)
Equity alliances			0.005			0.008				-0.002			-0.001	
			(0.002)**			(0.002)***				(0.001)			(0.001)	
M&A				0.02		0.047	0.059				0.007		0.015	0.022
				(0.006)***		(0.010)***	(0.010)***				(0.003)***		(0.005)***	(0.005)***
Non-equity					0.038		0.032					0.018		0.010
					(0.009)***		(0.006)***					(0.005)***		(0.003)***
Constant	-2.645	-2.684	-2.735	-2.594	-1.562	-1.534	-1.416	-0.793	-0.793	-0.86	-0.846	-0.533	-0.588	-0.570
	(1.055)**	(1.058)**	(1.039)***	(1.058)**	(1.112)	(1.099)	(1.105)	(0.392)**	(0.390)**	(0.397)**	(0.396)**	(0.395)	(0.404)	(0.398)
log lik	-1427.57	-1425.87	-1425.32	-1422.07	-1419.57	-1413.57	-1406.95	-3761.79	-3760.04	-3761.02	-3758.73	-3755.57	-3754.62	-3749.39
lr-test		3.28*	4.38**	10.88 ***	15.88 ***	27.87 ***	41.41 ***		3.51*	1.55	6.13**	12.46 ***	14.36 ***	24.81 ***

N=898; Dummy variables of year is included but not listed in the table; Standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%