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Technological exploration through licensing: new insights from the licensee's point of view

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The market for technology plays a crucial role in firms' technology strategy as a way to undertake search in the available technological space. Drawing on innovation search theory and the literatures on licensing and absorptive capacity (AC) we address the issue of the factors that affect how technologically distant from the existing technological portfolio in-licensing firms are able to move when they in-license externally developed technologies. We posit that a long technological distance reflects the outcome of more exploratory search, while a short distance reflects the outcome of exploitative search. We conjecture two distinct dimensions of AC in terms of the firms' stock of knowledge ("assimilation capacity") and the degree to which firms have searched broadly in the past ("monitoring ability") to affect the distance of exploration from the existing technological portfolio. Furthermore, we compare firms that explore through licensing and firms which do not explore through licensing, but do so through search reflected in own patenting activities. We propose that the effects of assimilation capacity and monitoring ability should be more pronounced for licensees. Combining data on 176 license agreements and related patent information and while using a control sample of non-licensing firms we find—with exceptions—support for these ideas.

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1. Introduction

The increasing importance of markets for technology is challenging the traditional model of organizing innovation, where R&D and the complementary assets required for innovation are largely integrated within the firm (Teece, 1988; Arora *et al.*, 2001a). The emergence of these markets has offered a new window of opportunity to firms that are more open to the outside and that are engaged in permanent search activity (Arora *et al.*, 2001b; Laursen and Salter, 2006). Indeed, given the fact that firms can rely on external sources of knowledge to feed their innovative capacity, the ability to explore the increasing amount of external sources of knowledge becomes more and more relevant for them. Recent empirical studies have found that increasing efficiency of markets for technology, and the associated declining transaction costs, make technology outsourcing an important alternative to in-house R&D in various industries (e.g. Silverman, 1999; Arora *et al.*, 2001b; Fosfuri, 2006; Lichtenthaler and Ernst, 2007).

The literature on licensing behavior has, however, mostly focused on the supply side of the technology market. Although this literature has greatly enhanced our understanding of the licensing phenomenon, the demand side of the market has generally been overlooked, with licensees assumed to play a passive role. As pointed out by Henry Chesbrough: "[b]oth the buying and the selling perspectives are necessary to improve the management of IP." (Chesbrough, 2003: 158). A small number of previous studies have examined the licensee perspective (e.g. Atuahene-Gima, 1993; Atuahene-Gima and Patterson, 1993; Lowe and Taylor, 1998) and only few of them have shed light on technology in-licensing as a diversification option (Killing, 1978; Caves *et al.*, 1983). These studies on technology in-licensing have found that the acquired licenses were most often closely related to the focal firm's technological competencies. However, from these contributions it is not clear to what extent markets for technology provide innovating organizations with greater strategic flexibility and a larger number of feasible options as compared to in-house search. We attempt to remedy this research gap by comparing the behavior of in-licensing firms to the behavior of comparable non-in-licensing firms.

Our analysis draws on the idea that firms can undertake two types of technological search and diversification: local search (or exploitation) and distant search (or exploration) and that firms' managers need to balance these two types of search (prominent examples include, March, 1991; Levinthal, 1997; Rosenkopf and Nerkar, 2001; Katila and Ahuja, 2002; Benner and Tushman, 2003; Gupta *et al.*, 2006). In this article, we assume that exploitative and exploratory search represent a continuum with "exploitation" and "explorations" as two extremes. From this perspective, we posit that a long technological distance reflects the outcome of more exploratory search, while a short distance reflects the outcome of more exploitative search and we identify characteristics of in-licensing firms that may lead them to explore or exploit through in-licensing.[1]

Cohen and Levinthal (1990) have defined absorptive capacity (AC) as the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (p. 128). We focus on two dimensions of AC, the monitoring/valuation/identification ability and the assimilation capacity. These two dimensions would both be included in what Zahra and George (2002) later dubbed "potential AC" (defined as the ability to acquire and assimilate externally generated knowledge)—as opposed to "realized AC" that has to do with how firms transform and exploit externally acquired knowledge to commercial ends. Several later studies have refined and extended the AC construct (Jansen *et al.*, 2005; Lane *et al.*, 2006; Fosfuri and Tribó, 2008). In this article, however, we suggest that two dimensions of AC in terms of the firms' stock of knowledge ("assimilation capacity") and the degree to which firms have searched broadly in the past ("monitoring ability") positively affects the distance of exploration from the existing technological portfolio. Moreover, we contrast firms that explore through licensing and firms which do not explore through licensing, but do so through search revealed in own patenting activities. We go on to suggest that the influence of assimilation capacity and monitoring ability should be more pronounced for licensees. To our knowledge, no previous work has tried to distinguish and operationalize these different dimensions of the AC construct and certainly not in the context of in-licensing strategy.

Our empirical analysis draws on a sample of 176 firms with license agreements over the period 1974–2001. We combine licensing information with related patent information and a number of other types of data. By using a control sample of non-licensing firms, we conduct an analysis with difference-in-difference characteristics that allows to assess the existence of significant differences in firms' ability to undertake technological exploration of varying degrees of distance from the firms' existing technological portfolio—through licensing-in or own patenting activity—across the two samples of licensing and non-licensing firms. With exceptions, we find overall support for our ideas.

2. Theory and hypotheses

The organizational theory of innovation and the theory of search have found that exploration and exploitation are pursued in different organizational settings, ranging from in-house search activity to alliances, acquisitions and licensing-in. Here we draw on Koza and Lewin (1998: 260) who argue that: "In licensing and franchising

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[1] Note that in-licensing is a way to acquire already existing external technology in the market. In that sense, we examine firms' ability to explore technologies that are new to the firm, not new to the world.

(from the point of view of the licensee), AC determines the rate and effectiveness through which technology, brands, and the like may be internalized." Many studies have explored the antecedents and consequences of AC. However, few scholars have tried to understand the implications of different dimensions of the AC construct for exploratory and exploitative search. For instance, in the context of strategic alliances, Mowery *et al.* (1996) measured AC in terms of the pre-alliance level of technological overlap with partner firms and found the extent of a firm's absorption of technological capabilities from its alliance partners to be positively related to its pre-alliance level of technological overlap with partner firms. Following Zahra and George (2002), subsequent research has tested the construct empirically by digging deeper into underlying mechanisms that affect potential and realized AC. In particular, Jansen *et al.* (2005) have examined organizational mechanisms, while Tribó and Fosfuri (2008) have shown that R&D cooperation, external knowledge acquisition and experience with knowledge search are important antecedents to potential AC. This view of AC then emphasizes the firm's ability to exploit external knowledge (Lane *et al.*, 2006: 855). Another important attempt at refining and extending the concept of AC has distinguished between explorative learning (monitoring), transformative learning (assimilation) and exploitative learning (apply it to commercial ends) (Lane *et al.*, 2006). Here, we build on this insight and use the concept of firms' *monitoring ability* to measure the degree to which they have searched broadly in the past.

Lane *et al.* (2006) claim that transformative learning (or assimilation) results from the combination of new knowledge with existing knowledge. Given that firms' exact combination of new knowledge with existing knowledge is very difficult to gauge, we use the concept of *assimilation capacity* from a different perspective and measure it in terms of the breadth of the firms' stock of knowledge. It can be noted that Jansen *et al.* (2005) measured assimilation in terms of firms' aptitudes to react to market signals. However, as we are dealing with the specific case of technological exploration—rather than with a multi unit service firm as in the case of Jansen *et al.* (2005)—we need to use an aspect of assimilation capacity in the technology rather than in the market environment (in line with Mowery *et al.*, 1996).

2.1 Technological exploration and assimilation capacity

Exploration increases variety, helping firms to minimize the risk of obsolescence which is particularly high under conditions of rapid environmental change (Sorensen and Stuart, 2000; Jansen *et al.*, 2005). The literature has pointed to the importance of cognitive obstacles to exploratory search, such as existing shared knowledge and organizational routines, communication channels and information filters, that makes it difficult for an organization to recognize and assimilate knowledge outside the scope of its core competencies (Nelson and Winter, 1982; Cohen and Levinthal, 1990; Henderson and Clark, 1990; Miller *et al.*, 2007). From this perspective, entry into new technologies or businesses appears to be different from a random walk because the access to new knowledge is costly and the cost of entry into a new technology increases with the distance from the firms' core knowledge and competencies (e.g. Granstrand *et al.*, 1997; Gambardella and Torrisi, 1998; Piscitello, 2000). Moreover, exploration of new technologies requires AC, an important antidote against the myopia of learning (Cohen and Levinthal, 1990).

As mentioned above, here, we use the concept of assimilation capacity and measure it as the breadth of the firms' stock of knowledge. As Cohen and Levinthal (1990) have pointed out "the ability to assimilate information is a function of the richness of the pre-existing knowledge structure: learning is cumulative, and learning performance is greater when the object of learning is related to what is already known . . . diversity of knowledge plays an important role . . . a diverse background provides a more robust basis for learning because it increases the prospect that incoming information will relate to what is already known." (p. 131). In this context, Lavie and Rosenkopf (2006) have noted that AC facilitates exploration through alliances. They also posit that a "broad AC" accumulated by interacting with a heterogeneous group of partners is important to explore new alliances (p. 803). We follow this line of argumentation and posit that a large assimilation capacity is associated with a broad AC in terms of a diversified technological background and that this capacity is important for future exploration. Accordingly:

> *Hypothesis 1: The broader the knowledge firms have accumulated (assimilation capacity) in the past, the more distant technological exploration from their technological portfolio they will (be able to) undertake in the future.*

2.2 Technological exploration and monitoring ability

According to Cohen and Levinthal (1990) and Lane *et al.* (2006), another important dimension of AC—in addition to the assimilation capacity—is the ability to recognize, identify and evaluate the potentiality of external knowledge. This capability is accumulated by screening the technological landscape. Katila and Ahuja (2002) developed the concept of search scope and operationalized it by using the share of new citations to total patent citations reported in a focal firm's patent stock. In this context, Katila and Ahuja (2002) argue that that search scope signals a firms attempt at exploring the technological landscape. We posit that backward citations in general indicate the firm's exploration of the technological space. Moreover, past exploratory activity, in our view, should enhance the firm's ability to screen and evaluate future external knowledge. Our proposition is in line with the idea discussed earlier; that past exploration induces more future exploration: "explorative tendencies, guided by AC, intensify with firms' prior exploration experience" (Lavie and Rosenkopf, 2006: 803). These arguments lead us to conjecture:

> *Hypothesis 2: The broader firms have searched in the past (monitoring ability), the more distant technological exploration from their technological portfolio they will (be able to) undertake in the future.*

2.3 Assimilation capacity and monitoring ability between licensing and non-licensing firms

Based on earlier insights (Cyert and March, 1963), evolutionary economists such as Dosi (1982), Nelson and Winter (1982), Pavitt (1988) and Helfat (1994) have argued that search through firm-internal processes are almost always highly localized in that firms search along established trajectories created by past experiences, routines and heuristics. The constraints to exploration and diversification that are typical of in-house search are likely to be less stringent when exploration is pursued through licensing because of smaller upfront costs and lower technological and market risk (the licensed knowledge may have been used by the licensor before licensing). More generally, organizations operating in complex environments characterized by a diversified knowledge base or firms that enter a new knowledge domain have to draw on alliances and other inter-organizational learning mechanisms to increase their AC (Powell *et al.*, 1996; Lane *et al.*, 2006). However, earlier studies on licensing have suggested that technological trajectories that firms pursue when license-in new technologies are guided by their pre-existing technological background (Killing, 1978; Caves *et al.*, 1983; Chatterji, 1996; Lowe and Taylor, 1998; Kim and Vonortas, 2006). Accordingly, both licensing-in and internal technological exploration (or diversification) are somehow constrained by firms' previous experiences.

When a firm wishes to explore into a new technology that is more or less distant to what it already does, the firm has—in many, if not most cases—the possibility of exploring through in-licensing. It can also explore internally—either through searching in a different direction or by inventing around an existing patent. However, when a firm with *a given level of AC*—as measured by assimilation capacity and monitoring ability—(that can be utilized for internal development or for in-licensing), wishes to explore far away from its existing technological portfolio, one would expect that the firm should the able to explore further away when the exploration involves a license. This is mainly because the underlying technology has been developed by another organization with another set of skills and competences than the licensee. Indeed, in the case of licensing-in, the licensee will possess both its own knowledge and the knowledge entailed in the license. In addition to that, there may also be complementarities between the firm's AC and the in-licensed knowledge that may further facilitate more distant exploration. Moreover—as pointed out above—licensing-in (like other inter-organizational mechanisms) entails a higher potential for more distant exploration than exploration through internal search due to the smaller up-front costs (for instance the costs associated with hiring and assimilating new technical staff) and lower technological and market risk in the former case. In other words, it is likely to be less costly to explore distantly through licensing-in. So the idea is that while the assimilation capacity and monitoring ability aspects of AC are important in the case of internal exploration they become important *a fortiori* in the case of exploration through in-licensing. In other words, external linkages such as licensing-in moderate the effect of AC on exploratory search. This leads us to conjecture:

> *Hypothesis 3a: Licensing-in reinforces the positive effect of a larger assimilation capacity on the distance of future technological exploration from firms' technological portfolio.*
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> *Hypothesis 3b: Licensing-in reinforces the positive effect of a larger monitoring ability on the distance of future technological exploration from firms' technological portfolio.*

3. Method

3.1 Data and sample

In order to test our hypotheses we developed a research design based on multiple sources of information on license and patent data. We started from the Intellectual Property database maintained by the Financial Valuation Group.[2] This database records IPRs transaction agreements concluded from the 1970s to the present, including the exchange of software, know-how, technology, copyright, patent, and products.

For the sake of our analysis we extracted only "patent" and "technology" transactions, identified in the database as such. This led us to an initial set of 1052 observations. For each transaction we could retrieve basic information on the document source, the date of the event and the source which reported the event, the names of the licensor and the licensee, their respective Standard Industrial Classification (SIC) and North American Industry Classification System (NAICS) industry codes and,—whenever available—the identification number of patents involved in the transaction. This information allowed us to cross-link the original dataset with many other sources of information that were necessary for our analysis.

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[2] The Financial Valuation Group (FVG) is one of the leading business valuation consulting and litigation service firms in North America. (http://www.fvginternational.com/index.html, accessed June 2007).

The first additional data source we used was the Security Exchanged Commission (SEC) website. We first searched for the original contractual document (License Agreement), or at least for some more detailed references concerning the transactions in other filing data (e.g. S1, 8K, 10K) in order for us to check both the reliability of data drawn from the FVG IP dataset, and to include these data in the dataset. However, the unavailability of key information caused the sample to drop substantially (firms often choose not to disclose central information for strategic reasons). In order to check whether a real transfer of patents had taken place and to exactly identify the type of technology involved in the agreement, we browsed the US Patent Office (USPTO) dataset according to the information available in the text of the contract. After this search and integration activity, we ended up with 301 patent agreements. However, given the specific purpose of our analysis, we included only those transactions that have been filed originally by the parties as (pure) licensing or assignment agreements, implying a one-way technology/IPRs transfer whereby the licensor maintains the ownership of the licensed/assigned technology.

At the end of this process we relied on a sample of 224 licenses involving almost 900 USPTO patents exchanged among licensor and licensee firms. In order to collect all relevant statistics on each licensed patent, we then matched our database with the National Bureau of Economic Research (NBER) dataset (Hall *et al.*, 2001) and its 2002 update. Given that we use patent citation to create the measure of monitoring ability, using USPTO patents is important because, unlike—for instance—European Patent Office (EPO) patents, a large number of citations are assigned by the patent applicant.[3] This observation makes the use of citations a reasonably good indicator of search conducted by the applicant during the inventive process.

At the firm level, we matched the available information on licensees' name and industry, with data on firm size measured by the number of employees drawn from proprietary or publicly available data sources, namely Thomson Research, Comp tech, Google Finance and, whenever necessary, company websites or other online available data sources. We then matched the name of our licensees with the patent assignee's names recorded in the NBER dataset (on some occasions, the patent was assigned to the parent company) to obtain their patent portfolios and related statistics for each patent.

In order to explore whether there are significant differences in search behavior between licensees and non-licensees and to understand the full implications of licensing activity and patterns, we also constructed a control sample consisting of non-licensee firms whose profile is similar to our treatment sample of licensees. Since our research design builds on patent data, we decided to compare licensees

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[3] See Criscuolo and Verspagen (2008). Recent studies have found that also in the USPTO about 40% of citations are added by patent examiners (Alcácer and Gittelman, 2006). Unfortunately, the information about the origin of citations (patentee or patent examiner) is revealed by the USPTO only for patents granted after January 2001.

and non-licensees that display a history of patenting activity over time. We picked up potentially matching firms from the whole set of USPTO patent assignees, relying again on the NBER patent dataset (2002 version). By doing so we ensured that both licensees and matched firms have dealt with patentable inventions. For the same reason, we first imposed a discriminatory condition according to which the matched company should have applied for a patent in the same 4-year time-span as the treatment company licensed-in a technology. Once we ensured the existence of this condition, we combined three extra criteria for matching. These are: same SIC code at the two-digit level; same region of the world (Asia, Europe or USA); and same patent portfolio size. Indeed, firm-size (in our case measured as the size of the patent stock), geographical localization and industry affiliation are all accepted as matching criteria in the literature (see for instance, Fosfuri *et al.*, 2008).

The matching procedure allowed us to identify a sample of potential matched non-licensees. We then manually checked (through the Thomson Research Database) whether each of the potentially matched firms had, in fact (i.e. missed by the FCGIP database), licensed in any technology around the year of the licensing firm's license. When no technology licensing activities were found in the Thomson Research Database, we proceeded by "googeling" the name of the company combined with the term "license agreement" to get all the possible publicly available information for that firm. Only in the cases where we were sure that the potential matching firms did not acquire a license in the relevant period, we included the firm in the matching sample. We considered ourselves to be sure when we detected material about the firms that included information about technological activity (typically, the firms' annual reports)—when we found no information on the given firm or the firm had licensing activity (this happened frequently), we deemed the potential match an unfit match and we went on to examine another potential match. We repeated this procedure eight times to increase the number of matched firms. In this way we ended up with 183 licensees that were matched up with 183 non-licensees, matched on a one-to-one basis.

A large difference in the average patent stock between the two samples led us to drop seven outliers from the treatment sample and their matched firms. The average patent stock for the treatment sample before dropping these outliers was about 319 patents against 34 patents of the matched sample. Our final sample then consists of 176 licensees and 176 non-licensees. Since firms can look for external knowledge using different channels than licensing-in, we also examined the patent documents of the two samples to find cases of co-assignment.

3.2 Measures

3.2.1 Dependent variable

Our dependent variable is the *distance of technological exploration* from the firms' existing technological portfolio pursued by firms through licensing (for licensing firms) or own patenting activity (for the matched non-licensing firms). Here distance should be understood as how overlapping the existing patent portfolio and the new (licensed-in or own) patent are. When the existing patent portfolio contains only a small fraction of patents in the same International Patent Classification (IPC) class as the new patent, the distance is considered high and when the existing patent portfolio contains a large fraction of patents in the same IPC code as the new patent, the distance is considered low.

Inspired by the *focus index* introduced by Ziedonis (2007) we took the citation-weighted sum of licensee *I's* granted patents that were applied for within 6 years of the time t of the license and are in the same primary four-digit IPC class as the class of the licensed patent (or at least in one of them if patents are more than one) divided by the citation-weighted sum of all patents issued to the licensee that were applied for by the time t of the license.[4] Our measure of distance of technological exploration is:

$$\text{Distance of technological exploration} = 1 - \left[\frac{\left(\sum_{t-6}^{t} \sum_{J} \tilde{C}_i p_{\grave{\imath}} \right)_c}{\left(\sum_{t-6}^{t} \sum_{J} \tilde{C}_i p_{\grave{\imath}} \right)} \right]$$

where $\left(\sum_{t-6}^{t} \sum_{J} \tilde{C}_i p_{\grave{\imath}} \right)_c$ is the citation-weighted (C_i) sum of firm *i*'s patents (p_i) that were applied for within 6 years at the time of the licensing decision t and are in the same primary patent class as the class c of the [licensed] patent under consideration; and $\left(\sum_{t-6}^{t} \sum_{J} \tilde{C}_i p_{\grave{\imath}} \right)$ is the citation-weighted sum of all patents issued to the firm (the licensee) that were applied for by date t (year of the license).[5] The greater the value of our index, the higher is the distance of technological exploration from the firms' existing technological portfolio.

Based on our matching procedure criteria, described above, we identified comparable firms that did not license any technology from external sources of knowledge in the relevant years of investigation. For these firms we computed the same index of exploratory search above calculated with internal patenting activity rather than licensed-in patents. That is, we computed the complement to one of the citation-weighted sum of non-licensee *I's* granted patents that were applied for within 6 years of the time t of the license and are in the same primary four-digit IPC class as the class of the newly in-house developed patent, divided by the citation-weighted sum of all patents issued to the firms that were applied for by the time of license, t.

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[4] We experimented with different time windows for the licensees' stocks of patents, and the empirical results are similar to those reported in this article.

[5] By using forward citations we account for differences in the value of different patents. Forward citations are correlated with other measures of patent value (Gambardella *et al.*, 2008).

3.2.2 Independent variables

Consistent with the aim of our article, we focus our attention on two key regressors that, we believe, make the difference when comparing licensee and non-licensee firms. They refer to licensees' characteristics, reflecting either their *assimilation capacity* or *monitoring ability*. We operationalized assimilation capacity by measuring firms' patent portfolio dispersion across technological classes. This choice is rooted in organizational research and innovation management. For example, Lane *et al.* (2006) have noted that "the breadth of knowledge that a firm understands determine how far its exploratory learning can venture from its existing knowledge base" (p. 855).

The greater the dispersion of a firm's technological background, the higher its ability to assimilate external technologies in distant, unfamiliar knowledge domains. We measure this ability as the complement to one of the Herfindahl index applied to licensees' patent portfolio composition as recorded at the time of license. This index reflects the degree of dispersion of the licensee's patents across different technological (four-digit IPC) classes and varies between 0 and 1: $1 - \sum_{i=1}^{n} \alpha_i^2$ where α_i is the share of patents in four-digit IPC class i in the firm stock of patents.

The higher the index, the broader the scope of the licensee's technological expertise and therefore, the more likely it will be able to enter new technologies. Firms with a dispersed patent portfolio have learned to manage different technologies and therefore should display a greater ability to enter into a new technological field compared with firms endowed with a narrow technological portfolio. We created the same variable for non-licensee firms. In doing so, we took care of excluding the patent(s) that have been applied for in the same year of the corresponding license, t, in order not to include it/them as it/they represent(s) the benchmark for the construction of the dependent variable.

The second variable reflects firms' past exploratory search activity and thereby firms' monitoring ability. The expected impact of past exploration (and monitoring ability) on future exploratory search is in line with the literature on organizational learning which posits that "exploration often leads to more exploration, and exploitation to more exploitation" (Gupta *et al.*, 2006: 695). Here, we follow earlier studies which have relied on backward citations as a measure of technological search (Katila and Ahuja, 2002). Our central proxy for past monitoring activity is the average number of backward citations reported in the focal firms' patent stock before the license announcement (*monitoring ability scale*). As mentioned before, backward citations signal a firms attempt at exploring the technological landscape over time. The higher the average number of citations, the larger is the scale of the firm's technological search activity. Accordingly, we assume that an intensive citation activity enhances the monitoring ability of the firm.[6]

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[6] It can be argued that firms whose patents contain many backward citations are exploring technological fields characterized by high IP fragmentation. From this perspective, backward citations are a

In order to account for the effect of technological diversity of backward citations we used another measure of monitoring activity: the number of four-digit IPC classes contained in the focal firm's backward citations divided by the number of the focal firm's own patents. While the average number of backward citations accounts for the scale of monitoring activity, the diversity of IPC classes contained in backward citations measures the breadth of monitoring activity. The larger is the breadth of citations the higher is the variety of knowledge sources the firm is aware of and, therefore, the greater is its *monitoring ability breadth*.

We computed the same central variables above for non-licensee firms, but we did not include in the count of backward citations those referring to the newly in-house developed patent as it stands as our baseline for the construction of the dependent variable. An alternative measure of past exploratory search activity would have been a variable reflecting past in-licensing experience. However, we have to rely on citations, given that our sample contains only very few firms with repeated license-in experiences.

3.2.3 Control variables

Licensing-in is one of several ways to acquire knowledge from the outside environment. Firms that adopt an open innovation model can rely on multiple forms of exploration of the technological space such as formal and informal R&D collaboration. To control for the effect of exploratory mechanisms other than licensing, we generated a dummy called *co-patenting* that takes value 1 if the firm has at least one co-assigned patent in its patent portfolio. We obtained this data from a recent addition to the NBER patent data set provided by James Bessen at http://www.nber.org/~jbessen/.

In addition, since we believe that firms' experience in patenting activity may have an impact on its distance of technological exploration from the existing technology portfolio at a given point of time, we account for this by introducing three different variables, including licensee's *patent stock*, licensee's *patent experience* and *patent activity*. The licensee' patent stock was obtained by counting the number of patents applied for by the licensee before the license announcement. We use it to control for the scale of innovative activities. Like the diversification of the patent portfolio described above, this could be viewed as another proxy for AC. However, it is a quite crude proxy of AC because it does not account for the composition of the firms' patent stock. Patent experience takes into account the lag between the license year and the year of issue of the licensee's first patent. This measure is supplemented with a dummy (patent activity), that takes value one if the licensee has been granted

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measure of the fragmentation of the market for technology rather than a measure of monitoring activity. However, even when the applicants of new patents have to explore highly dense technological landscapes to reduce the risk of infringement they are likely to improve their monitoring capability.

at least one patent all its life, and zero otherwise. We got this information from the USPTO database and from the Patent Genius database available online (http://www.patentgenius.com).

Moreover, we control for the degree of *generality* of the technology that the recipient firm in-licenses from outside, as generality is an important characteristic of technology that may affect our dependent variable (Bresnahan and Trajtenberg, 1995; Hall and Trajtenberg, 2004). For this purpose we rely on the Generality index reported in the NBER dataset for USPTO patents. The index varies between 0 (minimum generality, all citations received are concentrated in one technological field) to 1 (max generality, citations are highly dispersed across different fields) (Hall and Trajtenberg, 2004). For our purposes here, and given the fact that firms may have licensed more than one patent, we use the highest value of the generality index among all patents exchanged through each transaction.

According to the overall research design, we created the same variables for the non-licensee sample. We did not include the patent activity dummy since by definition it is equal to 1, given that non-licensees were sampled among the overall set of USPTO patent assignees. For the construction of the equivalent measure of the patent stock and patent experience we made sure not to include the focal patent that has been filed in the year of the corresponding license agreement. We also control for firm size by creating a categorical variable based on the number of employees—<100 (*small firm*), between 100 and 1000 (*medium firm*) and >1000 (*large firm*). We could have relied on the patent stock measure as proxy for size, but we decided not to do this, because very small firms may display an extensive patenting activity as compared to large firms. Finally, we controlled for industry dummies based on the SIC-code at the two-digit level as attached to the firm in question. However, SIC classes were aggregated into 11 broad industries to avoid a too small number of firms in each industry (we went for a minimum of 10 firms). We generated a dummy variable for each of these industries.[7] In our setting, industry dummies may account for unobservable environmental conditions, like technological and market uncertainty or appropriability conditions that may affect the degree of explorative search of the firm.

3.3 Econometric method

As our dependent variable is continuous we use ordinary least squares as the means of estimation. To utilize our control group we conduct an analysis with difference-in-difference characteristics that also allows for assessing the existence

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[7] Natural resources, supplier dominated manufacturing, drugs, chemicals and allied products, computer equipment, electronic and other electrical equipment and components (except computers), transportation, instruments, miscellaneous manufacturing, knowledge and information-based services (KIBS, communication, business, engineering, accounting, research, management, and related services), other services.

of significant differences in technological search patterns across the two samples that is needed to test Hypotheses 3a and 3b. However, as we focus on search behavior through licensing and on how far an acquired license is from the existing technology-base of the focal firm, our research design is inherently cross-sectional. For that reason, we do not strictly rely on the difference-in-difference estimator that analyses effects of a treatment over time (Wooldridge, 2002: 128–132). Here, we consider licensees to be our treatment group and non-licensees to be the control group. Our key independent variables are then considered to be the treatment. Concretely, and in order to allow us to compare the two samples we created a dummy called *licensee* that takes the value 1 if the 176 observations refer to the licensee firms, and 0 otherwise. By interacting this variable with the main regressors, we can assess the differences in technological search patterns across the two samples.[8] We also interacted the *co-patenting* variable with the main regressors to see whether the effect of licensing on the *distance of technological exploration* remains significant beyond that of other external sources of knowledge.

4. Results

4.1 Descriptive statistics and correlations

Table 1 summarizes descriptive statistics for each variable included in our regression analysis. Descriptive statistics are available for the pooled sample, the sample firms (licensees) and the control sample (non-licensees). Apparently, there are no significant differences between the two groups in terms of the distance of technological exploration (our dependent variable) and assimilation capacity (measured by the breadth of the firm's patent stock). However, it can be noted that the average number of citations in patents (our measure of monitoring ability scale) held by the treatment group is significantly smaller than the average citations in patents held by the control group (t statistics $= 3.3710$; $P = 0.000$). Instead, the treatment group have a greater monitoring breadth compared with the control group (t statistics $= -3.5505$; $P = 0.000$). Firms in the treatment group show on average a larger stock of patents before licensing, but the difference with the stock of the control sample is not statistically significant.

Table 2 shows the Pearson correlation coefficients of the variables included in the analysis. The correlations do not warrant further examination with respect to multicollinearity.

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[8] To check for sample selection bias we also estimated a sample selection model using the Heckman two-step method. The inverse Mills' ratio obtained from the first stage estimation obtained by a probit model was then entered in the regression equation. Results are in line with those showed in the paper.

Table 1 Descriptive statistics

	Pooled sample					Licensees (split sample #1)					Non-licensees (split sample #2)				
	Obs.	Mean	SD	Min	Max	Obs.	Mean	SD	Min	Max	Obs.	Mean	SD	Min	Max
Degree of technological exploration	352	0.83	0.31	0	1	176	0.84	0.30	0	1	176	0.82	0.31	0	1
Assimilation capacity	352	0.72	0.35	0	1	176	0.72	0.34	0	1	176	0.71	0.36	0	1
Monitoring ability scale	352	6.06	11.21	0	79	176	4.07	9.11	0	77	176	8.04	12.68	0	79
Monitoring ability breadth	352	8.84	37.06	0	353	176	15.74	51.44	0	353	176	1.94	3.53	0	25
Patent stock	352	24.00	158.28	0	2231	176	35.03	221.14	0	2231	176	12.97	33.17	0	211
Generality	352	0.48	0.39	0	1	176	0.57	0.35	0	1	176	0.39	0.42	0	1
Patent experience	352	5.53	8.26	−11	37	176	5.10	7.74	−11	37	176	5.97	8.75	0	34
Patent activity	352	0.85	0.34	0	1	176	0.71	0.45	0	1	176	1.00	0.00	1	1
Size	352	0.84	0.81	0	2	176	0.60	0.79	0	2	176	1.07	0.75	0	2
Co-patenting	352	0.09	0.29	0	1	176	0.07	0.26	0	1	176	0.11	0.32	0	1
Licensee	352	0.50	0.50	0	1	176	1.00	0.00	1	1	176	0.00	0.00	0	0

Table 2 Correlation matrix

	1	2	3	4	5	6	7	8	9	10
1. Degree of technological Exploration										
2. Assimilation capacity	0.33*									
3. Monitoring ability scale	−0.29*	−0.26*								
4. Monitoring ability breadth	−0.14*	−0.14*	−0.03							
5. Patent stock	−0.05	0.00	0.01	−0.03						
6. Generality	0.06	0.02	−0.02	0.02	0.02					
7. Patent experience	−0.13*	−0.11*	0.17*	−0.03	0.21*	0.06				
8. Patent activity	−0.21*	−0.32*	0.22*	0.10	0.06	−0.10	0.27*			
9. Size	0.11*	0.09	0.01	−0.09	0.16*	−0.02	0.27*	0.15*		
10. Co-patenting	0.03	−0.02	−0.03	0.03	0.28*	0.07	0.11*	0.13*	0.17*	
11. Licensee	0.03	0.01	−0.18*	0.19*	0.07	0.22*	−0.05	−0.41*	−0.29*	−0.08

*$P < 0.05$.

Table 3 reports the results of the OLS regressions analysis. Our dependent variable across the six models reported in this table reflects the distance of technological exploration from the firm's existing technological portfolio through licensing-in or own patenting. The first column reports estimation results for the baseline model (Model I) in which the two samples are pooled together and only control variables are entered, including the dummies for licensing and co-patenting. In Models II–IV we include the explanatory variables of theoretical interest one-by-one along with the controls. Model V includes interactions between the licensee dummy and the key regressors, namely assimilation capacity and the two dimensions of monitoring ability (monitoring ability scale and breadth). Model VI includes the interactions between the co-patenting dummy (instead of the licensee dummy) and the key regressors, while Model VII includes all variables and interactions. In unreported regressions we also estimated the same models above separately for the treatment sample and the control sample respectively.[9]

For the sake of simplicity, we focus our discussion on the full model in column VII. Hypotheses 1 and 3b find support in our data, whereas Hypotheses 2 and 3a are not supported. In Hypothesis 1, we conjectured that a greater assimilation capacity, measured by the diversification of the patent stock, increases the firm propensity to engage in more distant technological exploration, thus departing from its current

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[9] These estimations results are available upon request from the authors.

Table 3 OLS regressions: determinants of the distance of technological exploration

	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII
Assimilation capacity		**0.249*****	**0.219*****	**0.211*****	**0.149***	**0.205*****	**0.147***
		(0.061)	(0.061)	(0.060)	(0.080)	(0.063)	(0.082)
Monitoring ability scale			**−0.005*****	**−0.005*****	**−0.008*****	**−0.006*****	**−0.009*****
			(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Monitoring ability breadth				**−0.001**	**−0.006**	**−0.001**	**−0.005**
				(0.001)	(0.010)	(0.001)	(0.010)
Patent stock	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Generality	0.041	0.037	0.040	0.038	0.046	0.029	0.037
	(0.039)	(0.037)	(0.037)	(0.036)	(0.035)	(0.037)	(0.036)
Patent experience	−0.005**	−0.004**	−0.003	−0.003*	−0.004*	−0.003	−0.004*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Patent activity	−0.177***	−0.091**	−0.081**	−0.063	−0.070	−0.067	−0.077
	(0.037)	(0.041)	(0.041)	(0.043)	(0.050)	(0.043)	(0.050)
Medium firm	−0.038	−0.035	−0.024	−0.024	−0.026	−0.025	−0.026
	(0.045)	(0.043)	(0.043)	(0.043)	(0.043)	(0.043)	(0.042)
Large firm	0.133***	0.118***	0.111***	0.109***	0.102***	0.109***	0.102***
	(0.037)	(0.037)	(0.036)	(0.036)	(0.034)	(0.036)	(0.034)
Natural resources	−0.093	−0.049	−0.069	−0.076	−0.069	−0.070	−0.062
	(0.135)	(0.124)	(0.125)	(0.127)	(0.117)	(0.129)	(0.119)
Supplier dominated manufacturing	−0.063	−0.074	−0.082	−0.079	−0.073	−0.078	−0.074
	(0.061)	(0.060)	(0.059)	(0.059)	(0.057)	(0.059)	(0.057)
Other chemicals	−0.038	−0.027	−0.040	−0.039	−0.033	−0.034	−0.027
	(0.060)	(0.059)	(0.057)	(0.057)	(0.054)	(0.057)	(0.055)

(continued)

Table 3 Continued

	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII
Computers and computer equipment	0.066	0.044	0.028	0.024	0.013	0.026	0.014
	(0.063)	(0.062)	(0.057)	(0.058)	(0.06)	(0.057)	(0.060)
Electronic and electrical equipment	−0.016	−0.016	−0.026	−0.027	−0.027	−0.025	−0.026
	(0.065)	(0.062)	(0.063)	(0.062)	(0.059)	(0.063)	(0.06)
Transport equipment	0.041	0.050	0.040	0.040	0.057	0.037	0.050
	(0.065)	(0.07)	(0.067)	(0.068)	(0.073)	(0.069)	(0.072)
Instruments	−0.086	−0.040	−0.032	−0.030	−0.024	−0.034	−0.027
	(0.063)	(0.062)	(0.061)	(0.061)	(0.059)	(0.061)	(0.059)
Miscellaneous manufacturing	−0.125	−0.123	−0.116	−0.121	−0.120	−0.116	−0.116
	(0.102)	(0.091)	(0.086)	(0.087)	(0.090)	(0.087)	(0.091)
KIBS	−0.158*	−0.185**	−0.199**	−0.202***	−0.199**	−0.200**	−0.198**
	(0.082)	(0.078)	(0.077)	(0.077)	(0.078)	(0.078)	(0.078)
Other services				Benchmark			
Co-patenting	0.056	0.045	0.034	0.038	0.050	0.092	0.099
	(0.054)	(0.051)	(0.052)	(0.048)	(0.048)	(0.149)	(0.143)
Licensee	−0.023	−0.002	−0.019	−0.002	−0.166*	−0.002	−0.162*
	(0.041)	(0.041)	(0.04)	(0.04)	(0.097)	(0.041)	(0.098)
Licensee × assimilation capacity					**0.143**		**0.133**
					(0.119)		(0.119)
Licensee × monitoring ability scale					**0.008*****		**0.009*****
					(0.003)		(0.003)

(continued)

Table 3 Continued

	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII
Licensee × monitoring ability breadth					**0.005**		**0.004**
					(0.01)		(0.01)
Co-patenting × assimilation capacity						−**0.079**	−**0.088**
						(0.163)	(0.153)
Co-patenting × monitoring ability scale						**0.005**	**0.007***
						(0.003)	(0.004)
Co-patenting × monitoring ability breadth						−**0.002****	−**0.002****
						(0.001)	(0.001)
Constant	1.036***	0.768***	0.818***	0.810***	0.889***	0.821***	0.900***
	(0.071)	(0.100)	(0.095)	(0.095)	(0.094)	(0.096)	(0.095)
N	352	352	352	352	352	352	352
r^2	0.14	0.20	0.23	0.24	0.26	0.25	0.27

Bold typeface indicates variables of key theoretical interest.

$^*P<0.1$, $^{**}P<0.05$, $^{***}P<0.01$. Heteroscedasticity-consistent standard errors.

knowledge base. In Table 3 the coefficient for assimilation capacity is positive and remains significant below the 5% level when all controls are included in the equation. Contrary to our expectations (as stated in Hypothesis 2), the coefficient for past exploratory search (monitoring ability scale) is negative and statistically significant at the 1% level. Estimates based on the treatment sample and the control sample separately, however, show that this effect is driven by the control group. We recall that this group has a significantly larger monitoring ability scale than the licensee group. Accordingly, it is plausible that a more intense past exploration leads non-licensing firms to concentrate technological activities on the core competencies rather than exploring the technology space further. Monitoring ability breadth does not enter the equation significantly.[10]

Pertaining to Hypothesis 3a, we test the idea that licensing-in reinforces the positive effect of a large assimilation capacity (a broad patent portfolio) on the distance of future exploration from the firm's existing patent portfolio. This amounts to say that we expected that licensing moderates the effect of assimilation capacity on the distance of exploration. The coefficient on the interaction between licensing and assimilation capacity in Models V and VII is positive as expected, but it is not significant at the conventional levels. Hence, our results do not lend a strong support to Hypothesis 3a, suggesting that firms with a strong assimilation capacity have greater propensity to explore the technology market regardless of their involvement in licensing-in. In other words, we do not find evidence to suggest that the result obtained concerning assimilation capacity in affecting technological exploration (Hypothesis 1) is driven by the group of licensees. The insignificant coefficient for the interaction between assimilation capacity and technological collaboration (co-patenting) in Models VI and VII suggests that the impact of assimilation capacity on technological exploration is not affected substantially by the firm use of different external sources of knowledge.

In Hypothesis 3b, we predicted that the interaction between licensing-in and a large monitoring ability (accumulated through past exploratory search) should lead firms to explore more distantly from their existing patent portfolio. While a large monitoring ability as such does not lead firms to explore far from the existing technological background, the combination of monitoring ability (scale) and the use of the technology market (licensing) yields a positive and significant effect on the distance of exploration. It is worth to note that while licensing-in moderate the impact of monitoring ability scale on the distance of technological exploration, it does not have significant impact on the association between monitoring ability breadth and the distance of technological exploration. This result reinforces the idea that it is the scale of past exploration, rather than its breadth that provides firms with monitoring ability which can be used in future exploration.

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[10] The impact of monitoring ability breadth on the dependent variable is different when the estimations are carried out on the two subsamples (treatment and control) separately.

The latter results are robust to controlling for co-patenting (Models VI and VII). This suggests that licensing-in offers firms endowed with monitoring ability an important opportunity to explore the technological space beyond and above other mechanisms such as co-patenting. The latter seems to have an insignificant effect on the distance of exploration. However, the interaction between co-patenting and our two key regressors yields effects that are similar to that of licensing-in. In particular, co-patenting reinforces the positive (albeit only weakly significant) effect of a large monitoring ability scale on exploration. The negative effect of monitoring ability breadth on exploration is difficult to explain and given that the result is not central to the current article, we will refrain from speculation in this case.

Concerning other control variables, all models show that the size of the patent stock has virtually no effect on the distance of technological exploration. This means that firms that have more familiarity with patents do not necessarily explore far from their existing technological background to capture the opportunities available in the market for technology. Firms with longer patent experience before the focal year (license-in or new patent application) and firms owning at least one patent (measured by our patent activity variable) all their life show a lower propensity to engage in exploration as suggested by the negative coefficients for these variables. These effects, however, become insignificant when all controls are included in the regression analysis (Model VII).

Finally, larger firms show a higher propensity to explore far from their technological background as compared to smaller firms. The weak association between firm size and assimilation capacity (Table 2) suggests that the effect of size is not mediated by technological breadth. By the same token, the weak association between size and monitoring abilities (Table 2) suggests that the positive effect of size on exploration is not mediated by a greater monitoring ability measured by monitoring ability scale and breadth. Larger firms, then, are probably in a better position to explore the technological landscape for organizational reasons, such as a better division of labor in innovation and related activities.

5. Discussion and conclusions

This article began by observing that the existing literature on technology licensing mostly focuses on firms' choices as to whether to produce an innovation in-house or to license it to another firm, while only few studies examine how firms use in-licensing as a part of their overall technology strategy. In this article, we have focused on the distance between the technology acquired by licensing-in and the firm's existing technological portfolio. We posited that a long distance indicates the outcome of exploratory search whereas a short distance reveals the outcome of more exploitative technological search. The underlying idea is that the degree of exploration through licensing-in is shaped by two distinct dimensions of AC—assimilation capacity and monitoring ability.

Our empirical analysis showed that assimilation capacity is an important determinant of the ability to explore distantly from the firms' existing technological portfolio. The negative sign of monitoring ability scale was, however, unexpected. Although our cross sectional design does not allow for a dynamic explanation of this result, we can speculate that firms alternate phases of exploration, whereby they monitor the external technological space, with phases of exploitation during which they assimilate and further develop what they have learned from past exploration. This reasoning is in line with the proposition that exploration and exploitation are complements in the long run but are likely to be substitutes at a given point in time (they are synchronically substitutes).

Moreover, our findings showed that licensing-in has a moderating effect on the relationship between monitoring ability scale and the distance of technological exploration. Firms with large monitoring ability scale (acquired through past exploratory search) which rely on licensing-in, explore more distantly from their existing technological portfolio as compared to similar firms that do not rely on licensing-in. The positive effect of the interaction between monitoring ability and licensing points to the importance of markets for technology in the exploration of the technological landscape in search for new knowledge. It also suggests that gaining access to distant, unfamiliar, technologies through the market for technology requires prior investments in monitoring ability. This result is in line with the idea put forth by Cohen and Levinthal (1990) stating that knowledge is not a public good and requires specific investment to be absorbed. Markets for technology can reduce, but not eliminate, the costs of access to external knowledge. Our analysis suggests that the more distant is the knowledge that a firm seeks to acquire in the market for technology, the greater the total cost of acquisition which consists of an explicit component (the license fees) and an implicit component (the cost of AC). The latter is difficult to measure, but it is important to recognize for R&D and IP managers. The reason why firms endowed with strong assimilation capacity (measured by the breadth of their patent portfolios) do not rely on licensing in particular to explore new technological fields is less clear. We can speculate that firms with strong assimilation capacities do not need the market for technology to gain access to new technological fields—these fields can be reached through in-house exploration.

Our study extends previous research in the following directions. First, we contribute to the literature on the markets for technology (Arora *et al.*, 2001b; Fosfuri, 2006) by having focused on the demand-side of this market; an issue that has been generally under researched so far. Second, our article makes a contribution to the literature on technological search and open innovation (e.g. Katila and Ahuja, 2002; Laursen and Salter, 2006) by having shedded new light on the role of licensing-in as a strategy to capture new technological opportunities outside the boundaries of the firm. Several earlier studies have analyzed the role of various types of alliances as a learning mechanism, particularly when firms explore new businesses (e.g. Kogut and Zander, 1992; Khanna *et al.*, 1998), but there is still limited research concerning licensing-in as a mechanism of exploration.

Third, our analysis focuses on different dimensions of AC as antecedents to technological exploration. Several previous studies have further developed the notion of AC following the seminal paper by Cohen and Levinthal (1990); (Mowery *et al.*, 1996; Zahra and George, 2002; Jansen *et al.*, 2005; Lane *et al.*, 2006). However, the papers with an empirical component have either not dealt with the dimensions of AC relevant to technological exploration (Jansen *et al.*, 2005) or have claimed to measure AC in general (Mowery *et al.*, 1996). By having made the distinction between assimilation capacity and monitoring ability, we see this article as a first step towards breaking down the multi-level AC concept into components relevant to technological exploration. More in particular, however, our contribution regarding AC lies in the fact that no previous work—to our knowledge—has attempted to examine the implications of AC in the context of licensing-in. This is a significant contribution given the rising importance of the market for licensing (Arora *et al.*, 2001b; Robbins, 2006).

We acknowledge that interpreting the complex interactions among assimilation capacity, monitoring ability, and technology licensing versus internal development is a very difficult task which deserves further scrutiny, possibly based on further analysis and in-depth case-studies. One possibility is that assimilation capacity and monitoring ability are not independent drivers of the distance of exploration, but one of them is a mediator through which the other translates into more distant exploration. For example, one could argue that monitoring ability will translate into increased exploration through the development of assimilation capacity.

Another limitation to this study is that we have focused on a cross-section of licensing agreements. This prevents us to account for firm-specific unobserved heterogeneity. Collecting information on licensing agreements to obtain a panel dataset with a significant longitudinal dimension remains the object of future research. We have used only rough control variables (in particular industry-level dummies) that can somehow be said to reflect environmental pressures including market or technological uncertainty. Although our dependent variable is reflecting something that goes on in the technological domain—and not successful commercialization of the technology—it would also have been desirable to control for downstream complementary assets. Despite the fact that our matched sample approach can alleviate some of these problems, future research would benefit from the use of finer grained controls. Nevertheless, we believe that this article is a significant first attempt at better understanding the trajectories of firms' in-licensing behavior and their association with firms' learning capabilities.

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