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I Never Promised you a Rose Garden: An Analysis of the Rent Dissipation and Revenue Effect in Technology Licensing

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Abstract

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Over the last two decades licensing has experienced an unprecedented growth. Nowadays, these agreements represent one of the most important and fast growing methods of interfirm arrangements related to commercialization and diffusion of new technologies (Anand and Khanna, 2000). Surveys conducted by Gambardella (2005), Robbins (2008) and Pluvia Zuniga & Guellec (2009) show that among the main motivations for companies to license-out technologies is the revenue that it generates. That is, the present value of the fixed fee and/or the royalties that the licensee has to pay to the licensor (Arora and Fosfuri, 2003). However, firms may also experience negative effects from licensing-out their technologies. More specifically, the rent dissipation effect has been described as potential reduction of the licensor?s market share or price cost margin as a result of the additional competition in the product market (Fosfuri, 2006). Accordingly, prior studies indicate that the decision to license a technology is grounded on the interplay between the revenue and rent dissipation, with licensors seeking to increase the revenue and decrease the negative changes on

market share caused by licensing-out technologies to potential competitors (Arora & Fosfuri, 2003).

In this paper we develop a model to explain how the degree to which a licensed technology is related to licensor?s core technology affects the rent dissipation effect and the way that licensors try to secure a fixed remuneration condition in licensing contracts. Previous research has indicated that the closer a licensed technology to licensors core technological activities, the higher will be the commercial value and lower the uncertainty attached to it (Choi, 2002). Furthermore, we build on Gambardella and Gitarrana (2011) proposition that market structure conditions are an important determinant of the decision to license-out, and include in our analysis the level of technological fragmentation between licensor and licensee as critical moderator for the relationship between core technologies and rent dissipation and revenue effect.

We test our hypotheses using a sample of 169 licensors involved in licensing contracts within US pharmaceutical industry during the period of 1984 ? 2004. We use supplemental data from COMPUSTAT and the United States Patent and Trademark Office - USPTO to obtain specific characteristics of licensors, licensees and the licensed technology. A Major strength of our dataset regards the fine-grained information that we could obtain from the licensing contracts which allowed us to combine three different data sources. We used two econometric models to assess our hypotheses. First, a logit model was applied to predict the likelihood that a licensing contract will include a minimum royalty fee clause. We consider that the presence of this clause represents a stronger case in terms of remuneration structure within the licensing contract. According to our hypotheses, licensors will be more likely to evoke, and licensees to accept, this clause as a way to secure monetary compensations independently on how the licensee will be able to exploit the licensed technology. Second, we used a fixed effect model to predict the relative changes in licensor?s market share in the product market. The results offered robust support to most of our hypotheses.

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I Never Promised you a Rose Garden: An Analysis of the Rent Dissipation and Revenue Effect in Technology Licensing

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This paper analyzes the interplay between the rent dissipation and revenue effects by focusing on the degree to which the licensed technology represents a licensor's core activity. We argue that if companies are anticipating the future loss in their market share (Rent Dissipation Effect) that licensing will imply, they would try to overcome or reduce this loss asking for a minimum guaranteed revenue at the time to sign the agreement (Revenue Effect). The analysis revealed that the decision to license valuable technologies are significantly associated with a lower growth on the licensor market share and that licensors try to counter balance this effect by requiring stronger remuneration clauses in the contracts.

Key words: Technology Licensing, Revenue Effect, Dissipation Effect, Markets for Technology

INTRODUCTION

Over the last two decades licensing has experienced an unprecedented growth (Zuniga & Guellec, 2008; Kamiyama et al. 2006). Nowadays, these agreements represents one of the most important and fast growing methods of interfirm arrangements related to commercialization and diffusion of new technologies (Anand and Khanna, 2000; Hagedoorn, 2002; Somaya et al., 2010). Surveys conducted by Gambardella (2005), Robbins (2008) and Pluvia Zuniga & Guellec (2009) show that the main motivation for companies to license-out technologies is the revenue that it generates. That is, the present value of the fixed fee and/or the royalties that the licensee has to pay to the licensor (Arora and Fosfuri, 2003). However, firms may also experience negative effects from licensing-out

their technologies. More specifically, the rent dissipation effect has been described as potential reduction of the licensor's market share or price cost margin as a result of the additional competition in the product market (Fosfuri, 2006). Accordingly, prior studies indicate that the decision to license a technology is grounded on the interplay between the revenue and rent dissipation, with licensors seeking to increase the revenue and decrease the negative changes on market share caused by licensing-out technologies to potential competitors (Arora & Fosfuri, 2003; Fosfuri, 2006).

Firms have recognized the existence of this trade-off related to revenue and rent dissipation. According to the managing director of an intellectual property consulting company called Intercap: *'*On one hand, you don't want to abandon your patents' ability to exclude competitors from your market. But, on the other hand, you could be talking about hundreds of millions of dollars in new revenue from strategic licensing' (Kline, 2003). Following this trend, not only small firms lacking the necessary resources to generate commercial value out of their innovations, but also large established ones such as IBM, Philips Petroleum, AT&T and DuPont have actively used licensing as an strategic alternative to profit from investment in inventive activities (Rivette and Kline, 1999; Arora and Fosfuri, 2003). In this context, licensing has become a major instrument for firms to generate revenue by giving away proprietary know-how on specific technological assets in exchange of monetary compensations (Arora and Gambardella, 2010; Gans and Stern, 2010).

Despite the fact that prior studies have shown the existence of a 'licensing dilemma' faced by licensors, little empirical research has been done to understand the main drivers of rent dissipation and revenue effect. As a consequence, although it is evident from the extant literature that licensors will try to manage the trade-off involving licensing, it is not clear how certain contingencies regarding technology and firm (licensor and licensee) characteristics will influence these two effects. Fosfuri (2006) offers one of the few econometric investigations on this topic by looking into

how the intensity of the competition in the product market affects firms' rate of technology licensing. Complementarily, Choi (2002) uses economic modeling to demonstrate how contractual clauses (more specifically the grant-back clause) can be used to alleviate the dissipation effect. In a similar direction, some studies concerned with the remuneration structure of licensing contracts have focused the optimal payment scheme in order to avoid licensee's opportunistic behavior (e.g., Arora, 1996; Vishwasrao, 2007; Sakakibara, 2010). However, none of these studies have directly looked into the relationship between technology licensing and the changes on licensor's shares in the product market. Additionally, few studies have looked into the determinants of the remuneration conditions of licensing contracts (e.g., Arora, 1996; Sakakibara, 2010). Finally, although the licensing dilemma has been suggested to be one of the main determinants of the decision to license-out technologies, to the best of our knowledge no study has examined rent dissipation and revenue effect within the same context.

In this paper we aim to contribute to the literature on technology licensing by focusing on the degree to which the licensed technology represents a core technological activity to the licensor. Previous research has indicated that by licensing-out peripheral, instead of core, technologies licensors can limit the rent dissipation effect (Choi, 2002). From the licensors' point of view, this strategy would be an optimum way to generate revenue out of licensing activities without ceding its competitive position in the product market. However, from the licensees' point of view, acquiring licensors' core technologies constitutes a more attractive option, since those technologies are more likely to present a lower degree of uncertainty and more valuable commercial applications (reference). Therefore, by considering the licensed technologies within a continuum ranging from peripheral to core we expect that licensing-out core technologies licensors will experience a stronger reduction in their relative share in the product market. On the other hand, it is also expected that by acquiring licensors' core technologies licensees are more likely to accept a stronger case in terms of remuneration structure in a licensing contract.

Additionally, we propose that the relationship between licensing core technologies and the trade-off regarding the remuneration conditions and changes in licensors market share are contingent upon two major factors. First, we expect that the similarities between licensor and licensee in terms of technological capabilities will moderate the main relationship mentioned above. Licensing-out to a firm working on similar technology fields makes it more likely that the licensee will successfully apply the newly acquired technology in the same niches within the product market (Davis, 1977; Leone and Reichstein, 2012). Accordingly, we also expect that licensing contracts dealing with the transaction of core technologies and involving licensees and licensors with similar technological capabilities will be more likely to include stronger conditions in terms of remuneration structure. Second, based on the absorptive capacity literature we expect that licensees will differ in terms of their capacity to assimilate and, therefore, make use of a licensed-in technology (Laursen et al., 2010). As a consequence, licensing-out core technologies to a licensee with stronger capacity to assimilate external knowledge is likely to amplify the negative changes on product market share experienced by licensors. We also expect that licensee's assimilation capacity will increase the likelihood that licensors will request more favorable and less risky remuneration conditions in contracts involving licensees with stronger capacity to assimilate and deal with external knowledge.

This paper contributes to several streams of research. First, following concepts from markets for technology literature we offer an empirical test regarding the mechanisms behind the licensing trade-off. In doing so, we advance the research on technological licensing by focusing on firm and technology specific characteristics to explain the drivers of rent dissipation and revenue effect behind licensing contracts (Rivette and Kline, 1999; Arora and Fosfuri, 2003 Arora and Fosfuri, 2003). Second, drawing on absorptive capacity research we use the licensee's point of view to contribute to fill a stringent lacuna in licensing studies in what concerns the demand side of the markets for technology. So far the licensing literature has been almost entirely focused on the licensors' point of view (Arora and Gambardella, 2010). Prior studies have identified AC as a vital

capability to overcome competitors (Cohen & Levinthal, 1990). In the context of licensing studies, Koza and Lewin (1998) propose that 'In licensing and franchising Absorptive Capacity (AC) determines the rate and effectiveness through which technology may be internalized'. However, no study has yet discussed how the licensee's AC would affect the licensing trade-off.

We test our hypotheses using a sample of 169 licensors involved in licensing contracts within US pharmaceutical industry during the period of 1984 – 2004. We use supplemental data from COMPUSTAT and the United States Patent and Trademark Office - USPTO to obtain specific characteristics of licensors, licensees and the licensed technology. A Major strength of our dataset regards the fine-grained information that we could obtain from the licensing contracts which allowed us to combine three different data sources. We used two econometric models to assess our hypotheses. First, a logit model was applied to predict the likelihood that a licensing contract will include a minimum royalty fee clause. We consider that the presence of this clause represents a stronger case in terms of remuneration structure within the licensing contract. According to our hypotheses, licensors will be more likely to evoke, and licensees to accept, this clause as a way to secure monetary compensations independently on how the licensee will be able to exploit the licensed technology. Second, we used a fixed effect model to predict the relative changes in licensor's market share in the product market. The results offered robust support to most of our hypotheses.

The paper is organized as follows. We present theoretical arguments and hypotheses for explaining under what circumstances licensors will experience a decrease in their share in the product market combined with the inclusion of a minimum royalty rate the licensing contract as a way to secure compatible monetary compensations. We then describe the databases used in this study and how the dependent and independent variables were calculated, following by the econometric technique used to estimate our models. Finally, we present the results and conclusion.

THEORY AND HYPOTHESES

Licensing

Licensors may choose to commercialize a technology by embedding it in a final product or by selling it directly (Teece, 1986). The decision between these two option lies primarily on two aspects. First, if the licensor controls the downstream assets necessary to successfully exploit the technology. Second, the efficiency of the intellectual property rights regime. Focusing on the first factor, Arora and Fosfuri (2003) show that licensors that possess the downstream assets have to compare the revenue generated from licensing against the rent dissipation effect created by stronger competition in the downstream market triggered by licensing. However, as the best of our knowledge, no studies have analyzed how companies could manage this trade-off. Previous research has mainly focused on how to limit the extent of the profit dissipation effect. In particular, they found that it is better to license out technology when the strength of the patent protection is high (Cohen et al., 2000; Arora and Ceccagnoli, 2006), when intellectual property refers to general technologies (Bresnahan and Gambardella, 1998), when intellectual knowledge are based on scientific knowledge (Arora & Gambardella, 1994), when the market share of the company is small (Fosfuri, 2006), when intellectual property are related to non-core technologies and to geographically separated markets (Patel and Pavitt, 1997; Granstrand et al. 1997) and when the competition in the product market is high (Arora & Fosfuri, 2003). From our point of view licensors has an additional option that the one of limiting the dissipation effect, for us, licensors can: 1) license out technology trying to limit the extent of the dissipation effect (licensing just old and peripheral technologies, …) or 2) license out whatever technology carefully balancing the licensing trade-off and, in turn, asking for a guaranteed revenue that overcome the dissipation effect.

Licensing Core Technologies

Core competences of the firm are specific accumulations of expertise resulting from previous investments and from learning by doing. They are considered the base of the company strategy and have to be controlled in order to guarantee the competitive advantage as well as the future development of the company (Phahalad and Hamel, 1990). The most efficient way to protect internal knowledge from competitors' imitation is through patents because they guarantee that just the inventor will use, make or sell these intellectual property rights during a specific period of time. Patents confer the inventor the rights to act as a monopolist and, in consequence, to benefit from the innovation. For instance, Xerox has exploited their seminal xerography patents during a period of almost 20 years increasing significantly their benefits. However, when the company was forced to license those patents, it witnessed how its market share was quickly reduced, its competitive advantage disappeared and its benefits dramatically reduced (Rivette & Kline, 2000). In this case the company was forced to license its technology, but this example put in evidence that licensing not just implies positive effects: even the company was receiving licensing revenues they were no enough to overcome the loss in the product market. Therefore, companies should carefully protect the technologies that are more vital for maintaining their competitive advantage and be conscious about the consequences of transferring this kind of knowledge to other companies. Following the latter argument, companies should not license their core technologies if they want to maintain their competitive advantage or, if they decide to license them, they would have to be sure that the licensing revenue will overcome the lost related with the dissipation effect.

Therefore, we would expect that companies that license out their core technology a) ask for a guarantee minimum revenue and b) significantly reduces their market share in the next years.

Hypothesis 1a: The closer a technology to the licensor's core technological activities, the greater the probability of guaranteeing a minimum royalty fee (guaranteed revenue effect)

Hypothesis 1b: The closer a technology to the licensor's core technological activities, the stronger the dissipation effect

Licensing core technologies to companies with similar technological capabilities.

In order to limit the extend of the dissipation effect, companies should license old and peripheral technologies (Patel & Pavitt, 1997) to companies that operates in distant sectors (Arora & Gambardella, 2010). Under these situations companies would not take so much advantage of the transferred knowledge and would not erode the licensor's market share. However, previous literature has shown that the licensing decision is subject to how technologically close are the patent portfolios of both companies, suggesting that idea and asset complementarity are important factors at the time to take the decision. (Arora & Fosfuri, 2003; Laursen et al. 2010). Even thought it is no the best situation for licensors, it is the best for licensees. Markets for technology are mainly characterized by asymmetric information between the parties, by difficulties to describe and to value the technology and by the uncertainty about the validity and applicability of the traded technology (Arora & Gambardella, 2010). Nevertheless, those problems are significantly reduced if the licensee belongs to a closer technological field. First, because they will be better able to figure out useful available technology, reducing search costs. Second, because it would be easier for them to evaluate, assimilate and apply the incoming technology (Cohen & Levinthal, 1990; Arora & Gambardella, 1994). Moreover, relatedness between the external knowledge and the firm's existing knowledge stock facilitates performance (Cantwell, Gambardella & Granstrand, 2004; Teece,

Rumelt, Dosi & Winter, 1994), promotes the integration of the knowledge and assists the understanding of the assimilation of the acquired knowledge.

In the context of strategic alliances, it has been shown that partners with similar resources improve the alliance outcomes. In particular, Mowery et al. (1997) proved that companies that are more similar before forming the alliance, "absorb" faster and better the knowledge from partners. Lane and Lubatkin (1998) show that pharmaceutical and biotech firms with similar knowledge bases facilitate alliance success. Finally, Ahuja (2000) demonstrated that alliance among technologically similar companies increase patenting after the alliance.

In the context of strategic diversification, also some studies have proved the benefits of moving in a technological closer field. Breschi et al. (2003) found that firms extend their activities to close technological fields because the existence of spillovers, complementarity and lower switching costs. Silverman (1999) found that firms usually diversify into areas where their technological resources are more relevant.

Then, knowing that licensing is more likely when the partner is technologically close and that the final outcome of this mix is better when partners have similar capabilities, licensors face a dilemma: 1) not license out their core technology to partners with similar capabilities because they will improve the technology and will overcome the licensor in the product market, or 2) license the core technology to companies with similar capabilities asking for a guarantee revenue that overcome the strong dissipation effect that the company will face.

We would expect that companies that decide to license out their technology will require to licensees a guaranteed revenue to overcome the reduction in their market share. In other words, we propose that licensors that license out their core technology to a company with similar technological capabilities, after balancing carefully the licensing trade-off, will ask licensees a guaranteed revenue

to compensate the loss of market share that they will suffer in the product market as consequence of having an additional company with the same technology.

Hypothesis 2a: The probability of guaranteeing a minimum royalty fee (guaranteed revenue effect) *on licensing agreements involving licensors' core technologies will be stronger when licensor and* licensee have similar technological capabilities

Hypothesis 2b: The greater the similarity in licensee's and licensor's technological capabilities, the stronger the dissipation effect caused by licensing core technologies.

Licensing to companies with greater Absorptive Capacity (AC).

Few studies have focused on the licensee's perspective at the time to sign the licensing agreement (Atuahene-Gima, 1993; Atuahene-Gima and Patterson, 1993; Lowe and Taylor, 1998). However, licensing-in is fundamental to licensees because of two main reasons. First, because they accelerate the innovation process by eliminating the research and development steps that the licensor has already done (Hagedoorn, 1993; Reichstein & Leone, 2012). Second, because they help to overcome the lack of enough resources or capabilities to develop a final output or to diversify into a new field (Shimbo, 2007).

Nevertheless, the speed at which the licensee will benefit from the new knowledge highly depends on the licensee's absorptive capacity (AC). In 1990, Cohen & Levinthal defined AC as the *"ability to recognized the value of new information, assimilate it, and apply it to commercial ends"*, where the ability to assimilate new information is dependent of the existing in-home knowledge. From their point of view, as more diverse is the background of the company, more robust is the existing knowledge and more likely is to interiorize in coming information. Even though several studies have reviewed and extended this definition (Zahra and George, 2002; Jansen et al., 2005; Lane et

al.2006; Fosfuri & Tribó, 2008), we follow Cohen & Levithal AC' s definition and posit that a more diversified technological background will imply a large absorptive capacity.

Licensees will use in an efficient way the new technology if they have accumulated enough absorptive capacity to assimilate it and to improve it (Cohen & Levinthal, 1990). Under this situation, licensees would understand deeper the new technology, translate it into broader purposes, and increase the likelihood of competing aggressively in the product market with the licensor.

Previous literature has identified AC as a vital dynamic capability to overcome competitors, however, none study have proposed to pay attention to it in order to limit the extend of the dissipation effect. From our point of view licensee's absorptive capacity is a important point that licensor should take into account at the time to balancing the licensing trade-off because it would imply a greater decrease in the licensor's market share. Therefore, we propose that licensors that license out their core technology to a company with greater absorptive capacity, after balancing carefully the licensing trade-off, will ask licensees a guaranteed revenue to compensate the loss of market share that they will suffer in the product market as consequence of having an additional company with the same technology.

Hypothesis 3a: The probability of guaranteeing a minimum royalty fee (guaranteed revenue effect) on licensing agreemen*ts involving licensors' core technologies will be stronger when licensees have* stronger capacity to assimilate external knowledge

Hypothesis 3b: The higher the licensee's capacity to assimilate external knowledge, the stronger the dissipation effect caused by licensing core technologies.

DATA, VARIABLES & METHODOLOGY

Data

The research setting for this study was the U.S. pharmaceutical industry. Firms in this industry produce and commercialize drugs, chemical components and technologies. We choose this setting mainly for three reasons. First, licensing is one of the most common methods of technology transfer among pharmaceutical companies. Second, the pharmaceutical industry is characterized as technology driven and research intensive, what make technological knowledge a critical component to develop and sustain competitive advantages (Janodia et al., 2008). Third, since we use patent data, we choose an industry in which firms routinely and systematically rely on patents to protect their inventions (Hagedoorn and Cloodt, 2003).

The data used to develop our empirical analysis come from three different sources. First, as the starting point, we used the Deloitte Recap Database to obtain the licensing contracts involving U.S. pharmaceutical firms. We choose this database because it is one of the most accurate sources of information regarding partnerships in the pharmaceutical industry, covering 25 years of deals between firms in this industry (Audretschand and Feldman, 2003; Schilling, 2009). Additionally, it allowed us to access the original licensing contracts from which we could extract precise information regarding the contractual and technological aspects of the licensing deals. Second, we used the names of licensees and licensors to retrieve information regarding patenting behavior from the National Bureau of Economic Research (NBER) patent database. After matching the firms in our sample with the NBER database we could obtain relevant information concerning inventive activity such as the number of patents that the firms had at the moment of the licensing contract and the age of the licensed technologies. Finally, we obtained the financial information used in our analysis by matching the licensors in our sample with the COMPUSTAT database.

Given the nature of our study we only focus on licensing contracts that met the following conditions:

a) Are unilateral licensing agreements, doing this we exclude other types of transactions like joint-ventures and cross licensing;
b) Involve only U.S. pharmaceutical firms. A large portion of licensing contracts in the pharmaceutical industry involves universities or other types of research institutions, those contracts were dropped out of our sample
c) The licensing contract include a commercialization clause which allows the licensee to commercialize the licensed technology without the need to incorporate it into a new product;
d) The licensed technology is linked to a patent or application number connected to the USPTO; and
e) The licensing contract is not an amendment or restatement of a prior deal.

After selecting the contracts that met those specifications we ended up with a set of 457 observations regarding 235 licensors. During the matching process with the NBER and COMPUSTAT databases we lost 123 observation regarding firms that could not be matched. Our final sample concerns 169 licensors involved in 334 licensing contracts between 1995 and 2004.

Variables

Dependent Variables

Market Dissipation Effect

We compute our variable as a continuous change in the licensor market share in the first year after signing a license contract. Following a similar approach to Ferrier et al. (2002), in the first step we

calculate the market share for licensors using the ratio between licensor's sales and the total sales reported in COMPUSTAT database (for four-digit SICs). Then, our final measure is derived from the differences in the logarithm of licensor's market:

Change in market share= $ln(MS_{t+1}) - ln(MS_t)$

Where MS_{t+1} represents the licensors market share in the first year after signing the license contract and MS_t at the same year. This measure can be interpreted as positive values representing an increase while negative values a decrease on licensors relative market share in the year subsequently to the license agreement.

Revenue effect

Capturing the revenue effect originating from licensing imposes several challenges. Prior studies have described this effect as the monetary compensation that licensors receive when licensing a technology (Fosfuri, 2006). The remuneration structure of licensing contracts may be set using fixed fees or royalties (Kats and Shapiro, 1986). However, given that very often licensing agreements are confidential, and it is not compulsory for firms to report in their fillings a specific statement indicating "licensing revenues", it is hard to disentangle the licensing contribution to the overall firm's revenues. Therefore, we operationalize our measure for revenue effect based on the information retrieved from the licensing contracts. We use a dummy variable indicating when the license contract will include a minimum royalty fee. The presence of a minimum royalty clause indicates that regardless of sales, the licensee has to pay the licensor a certain minimum royalty, even if the licensee has to supplement the earned royalty payments to reach that amount (Battersby and Grimes, 2009).

Focal Independent Variables

Technological proximity (core technology)

The variable varies from 0 to 1 and intends to capture how overlapping the patent portfolio of firm j and the licensed technology are, with greater values indicating that the licensed technology represents a licensor's core activity. Following the measure prosed by Ziedonis (2010, p 1625), this variable will be calculated as follows:

$$\text{Technological proximity} = \left[\frac{\left(\sum_{t-5}^{t}\sum_{j}\tilde{C}_i{\cdot}\rho_i\right)_c}{\left(\sum_{t-5}^{t}\sum_{j}\tilde{C}_i{\cdot}\rho_i\right)}\right]$$

In which $\left(\sum_{t-5}^{t}\sum_{j}\tilde{C}_i\cdot\rho_i\right)_c$ represents the citation-weighted sum of firm i's patents that were applied for within five years at the time of the license agreement t and belong to the same primary patent class c as the one of the licensed patent; and $\left(\sum_{t-5}^{t}\sum_{j}\tilde{C}_i\cdot\rho_i\right)$ is the sum of all citation-weighted patents issued to the firm j that were applied for by date t following the same time window of five years. The use of weighted citations offers the possibility to capture the relative importance of each patent within the firm's portfolio (Griliches, 1990). Additionally, Hall et al., (2001) call attention to the fact that the number of citations received by any given patent is naturally right-truncated in time, since it is only possible to observe the citations received so far. Furthermore, the fact that patents differ in age results in different degrees of truncation[1]. To overcome this issue we will use a multiplier factor developed by Hall et al., (2001) that corrects for the truncation problem by considering differences between the patent's grant years and the technological categories.

[1] According to Hall et al., (2001, p. 19) '50% of citations are made to patents at least 10 years older than the citing patent, 25% to patents 20 years older or more, and 5% of citations refer to patents that are at least 50 years older than the citing one'

Licensee capacity to assimilate external knowledge

Following the concepts found in the absorptive capacity literature we operationalize licensee's capacity to assimilate external knowledge by measuring how disperse its patent portfolio is across different technological areas. Prior studies (e.g. Cohen and Levinthal, 1990) suggest that firms with a broader knowledge base are more likely to present a critical overlap between new and existing knowledge components, which provides a deeper and useful understanding for exploiting externally acquired technologies. Therefore, we consider that the greater the dispersion of a firm's technological portfolio, the higher its ability to assimilate external knowledge acquired by means of technology licensing (for a similar application see Laursen et al., 2010). We operationalize this measure by using a Herfindahl index applied to the total number of patents contained in the licensee's portfolio accumulated during the prior 5 years to the license agreement:

Knowledge assimilation capacity= $1 - \sum_{j=}^{n} \left(\frac{N_{ij}}{N_i}\right)^2$

We use a 5 years moving window because the value of knowledge depreciate rapidly over time. Additionally, organizational memory, especially in high-tech firms, is highly imperfect implying that knowledge is not perfectly transferable overtime even within the same firm (Argote, 1999; Nerkar, 2003).

Similarity between firms' technological capabilities

We measure the similarity between licensors' and licenses' technological capabilities by examining the extent to which both firms patent in the same technology classes (Jaffe, 1986; Sampson, 2007). This measure is designed to capture the technological position of the licensor relatively to the licensee. In order to construct our measure we first generated separately the technological portfolio of licensees and licensors by measuring its distribution of patents across different patent classes in

the prior 5 years to the licensing agreement. Similar to prior studies (e.g., Sampson, 2002) we obtained a multidimensional vector, $F_i = (F_i^1 \ldots F_i^S)$, according to which F_i^s represents the number of patents assigned to firm i in the patent class s. This approach is based on the assumption that the distribution of licensors' and licensees' patents across technological classes reflects the distribution of its technological knowledge within different technological activities. Therefore, the degree of similarity in technological capabilities is given by:

$$\text{Technological similarities} = \frac{F_i F_j}{\sqrt{(F_i F_i)\,(F_j F_j)}}$$

Accordingly, this measures range from 0 to 1, with a value of 1 representing the highest possible value of similarity between the licensor and licensee.

Control variables

To minimize alternative explanations and isolate the effects of the explanatory variables, we controlled for several factors regarding firm, contract and technology characteristics that could also explain changes in market share. Regarding firm characteristics we control for size using the logarithm of the licensor's number of employees. Additionally, given that firms with a larger portfolio of patents would be less susceptible to experience dissipation effect caused by licensing a core technology, we control for the total number of patents that the licensor successfully filled in the prior 7 years to the focal year. We also considered that changes in market share are heavily influenced by firm's prior financial performance and for this reason we also added a control to try to capture the licensors' level of indebtedness by dividing the debt in current liabilities by firm sales. Finally, the last firm specific control added in our model was the number of technologies licensed-out at year t. In order to increase the robustness of our results by controlling for other

potential source of unobserved heterogeneity across firms we used firm and year fixed effects to estimate our models.

We also control for contractual specification by adding dummy variables capturing if the license contract includes sub-licensing and grant-back clauses. Another important control related to contractual characteristics regards the territory where the license is granted, we included two dummies capturing if the license is restricted to the US market or if the contract does not impose geographic limits (worldwide including US). Finally we added a variable to capture the age of the licensed technology; this variable was calculated based on the date that the patent application was filled in the USPTO office and the date of the licensing agreement.

Model Specification and Estimation

Based on our hypothesis we use different dependent variables to capture rent dissipation and revenue effect. Accordingly, we applied two modeling approaches. First, we estimated a fixed effects panel with robust standard errors predicting relative changes in the licensor market share. We decided to use firm fixed effects to try to capture unobserved heterogeneity which could lead to biased estimators (Greene, 1997). We choose this method based on the fact that this type of potential bias is commonly a concern in studies dealing with measures regarding corporate performance (Coles et al., 2012). Additionally, we also included year dummies to control for period effects, such as differences in macroeconomic conditions. Second, using the same explanatory variables, we run a logit predicting the likelihood that a licensing contract will include a minimum royalty fee. Following common econometric practice (Greene, 1997), we clustered the error term at the licensor's id to account for the fact that firms entering the sample multiple times may present correlated standard errors.

RESULTS

Descriptive statistics

Table 1 presents descriptive statistics for each variable included in our regression analysis. The correlation does not warrant further examination with respect to multicollinearity. As a robustness check we calculated the variance inflation factor (VIF) for each model and the results were below the rule-of-thumb value ten (Woodridge, 2009). We can observe a reasonable correlation between technological proximity and firm size, indicating that larger firms are less likely to license close technologies. The explanation for this effect lies on the fact that larger firms are more likely to have a more diverse patent portfolio. This relationship could raise concerns regarding endogeneity, given that larger firms would be less likely to license familiar technologies and at the same time more likely to present a higher share in the product markets. However, since our dependent variable is calculated to capture the relative changes, and not absolute values, on licensors market share we have no reason to expect biased estimators.

Insert Table 1

Table 2 reports the results of fixed effects panel for change in the licensor's market share. The first column reports estimation results for all the regression controls. In models II –V we include the explanatory variables one-by-one together with the controls. Model II introduces the main independent variable technological proximity. Model III includes the variable technological similarities and the interaction term between this variable and our main independent variable. Model IV is estimated with the variables regarding licensee assimilation capacity and the interaction with technological proximity. Finally, model V introduces simultaneously all the independent variables of our model.

Hypothesis 1a predicted that the closer a technology to the licensor's core technological activities, the stronger the dissipation effect observed on the licensors' relative market share. The results of

table 2 indicate that the variable technological proximity presents a negative and significant value across our models. Hypothesis 1b suggested that licensors are more likely to require a minimum royalty fee when the licensed technology constitutes a core technological activity. We can observe on table 3 that the variable technological proximity presents a positive and significant coefficient in all models. Regarding hypothesis 2 a, we tested if the similarities between licensor and licensee strengthen the dissipation effect caused by licensing out core technologies. The results indicate that the interaction between technological similarities and technological proximity is negative and significant at 5% level. Testing hypothesis 2 b, it is possible to observe that there is a strong and significant increase in the likelihood to include a minimum royalty fee in the cases that a core technology is being licensed to a firm with similar technological capabilities. Finally, looking at hypotheses 3 a and 3 b, we observe that while the interaction between licensee assimilation capacity and technological proximity is negatively associated with the changes in licensor market share, it does not present a significant influence on the likelihood that a contract will include a minimum royalty fee clause.

Insert Table 2

Insert Table 3

CONCLUSION, DISCUSSION & IMPLICATIONS

Because technology licensing has increasingly become a major vehicle for technology exchange, the understanding of the interplay between rent dissipation and revenue effect is fundamental to shed light on the factors behind firms' decision to license. We investigate the contingencies under which firms will be more susceptible to 1) experience the negative effects associated with licensing and 2) ask for monetary compensations as well. In particular, we focus on the degree to which

licensed technology is core for licensors. We argue that if companies are anticipating the future loss in their market share (Rent Dissipation Effect) resulting from licensing core technologies, they would try to overcome this loss asking for a minimum guaranteed revenue (Revenue Effect) at the time to sign the agreement.

We tested our hypotheses on a set of 169 licensors involved in 334 licensing contracts between 1995 and 2004 in the U.S. pharmaceutical industry. The data that we used come from three different sources: Deloitte Recap Database, NBER and Compustat. The analysis revealed that the decision to license valuable technologies are significantly associated with a lower growth on the licensor market share and that licensors try to counter balance this effect by requiring stronger remuneration clauses in the contracts.

This study contributes to markets for technology literature in two ways. First, because we analyze simultaneously the contingencies under which the intensity of the licensing trade-off can vary. The literature has tended to separate analysis of the revenue effect and of dissipation effect. Regarding the revenue effect previous literature have focused on determining what is the optimal payment for avoiding licensee/licensor opportunistic behavior (Arora, 1996; Vishwasrao, 2007 and Sakakibara, 2010). We have added value to this literature because we analyzed how the characteristics of the technology traded and the characteristics of the parties affect to the economic requirements at the time to sign the licensing agreement. Regarding the dissipation effect, previous literature has focused on studying 1) specific circumstances and 2) characteristics of the licensed technology that limit the extent of the dissipation effect (Patel and Pavitt, 1997; Arora and Gambardella, 1998 Arora & Fosfuri, 2003; Cohen et al., 2000; Arora and Ceccagnoli, 2006). We contribute to this field because we empirically corroborate the existence of the dissipation effect under some of these circumstances and we have proved that companies are conscious of this effect and that try to balance it asking for a guaranteed revenue. Second, because this is the first study that analyzes the

licensing trade-off resulting from licensing core technologies. Previous literature has recommended not licensing core technology to limit the extent of the rent dissipation effect. We have shown that companies not necessarily have to focus on limiting its extent, they can also increase the revenue effect to balance the licensing trade-off and overcome the future loss in the product market.

This paper has also several limitations. The first one is related with the revenue effect proxy. We are supposing that the guarantee minimum royalty that licensors ask at the time of signing the contract will somehow overcome or reduce the dissipation effect. However, we just have a binary variable that is equal to one if licensors have required this clause or zero otherwise. Therefore, we exactly don't know until what point companies are anticipating the future loss in the product market. No doubt, we consider that this requirement in the licensing agreement is a signal of an effort to do it.

From our point of view, our results cannot be generalized to the whole population. This is mainly for three main reasons: 1) the pharmaceutical industry is characterized because it heavily relies on patents to protect their inventions, 2) in this sector licensing is the most common way of technology transfer and 3) United States is the most develop environment for Market for Technology. Therefore, we cannot expect that in sectors neither in countries that don't have so much licensing's experience accumulated, companies follow the same behavior.

From a practical point of view, this paper provides some insights that companies should take into account. First, since we have corroborated the existence of the rent dissipation effect, it is really important that managers take conscious about it and carefully balance the licensing trade-off before taking the licensing decision. Second, it is also important that managers learn that not licensing core technologies not is always the right strategy. Under this situation, managers have two options: 1) not licensing core technology to limit the dissipation effect or 2) guarantee the revenue effect to overcome the future loss. Third, it is important to have into account the absorptive capacity of the

licensee at the moment to license valuable technology. We have proved that in this case the market share of licensor is reduced in the next year and that, however, no strategy has been taken to anticipate this loss.

Table 1: Simple correlation among the independent variables

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Technological Proximity	0.351	0.299	1.00												
2. Technological Similarities	0.304	0.336	0.11	1.00											
3.Licensee Assimilation Capacity	0.652	0.291	0.10	-0.11	1.00										
4. Log(Employees)	5.978	2.666	-0.36	-0.11	-0.18	1.00									
5. Debt in Current Liabilities / Sales	19.184	78.811	-0.19	-0.09	-0.09	0.50	1.00								
6. Log(Licensor Number of Patents)	3.457	2.066	-0.22	-0.05	-0.13	0.65	0.20	1.00							
7. Log(Licensee Number of Patents)	3.333	2.666	0.19	0.25	0.21	-0.39	-0.11	-0.36	1.00						
8. Number of Licensed Technologies	5.965	10.137	0.01	-0.04	0.11	-0.07	-0.03	0.09	-0.07	1.00					
9. Sub-licensing	0.724	0.448	0.17	0.02	0.04	-0.10	-0.01	-0.06	0.00	0.01	1.00				
10. Exclusive Licensee	0.742	0.438	0.21	-0.01	0.20	-0.21	-0.05	-0.16	0.08	-0.01	0.44	1.00			
11. Grant-Back Clause	0.232	0.423	0.08	0.13	-0.04	-0.05	-0.07	-0.03	0.10	-0.05	0.05	0.17	1.00		
12. Patent Territory	1.368	0.896	-0.07	-0.01	-0.02	0.27	0.15	0.16	-0.06	0.10	0.06	-0.14	-0.14	1.00	
13. Technology Age	6.634	3.675	-0.19	0.01	-0.13	0.20	0.06	0.23	-0.13	0.05	-0.12	-0.23	-0.12	0.01	1.00

Table2: Fixed effects panel for change in market share

Dependent variable: ln(MS t+1) - ln(MS t)	model I	model II	model III	model IV	model V
Technological Proximity		-0.753*	-0.875**	-0.727*	-0.809**
		(0.325)	(0.289)	(0.284)	(0.255)
Technological Similarities			0.555*		0.505*
			(0.217)		(0.206)
Technological Proximity x Technological Similarities			-1.062*		-1.351**
			(0.487)		(0.495)
Licensee Assimilation Capacity				-0.144	-0.095
				(0.184)	(0.170)
Technological Proximity x Assimilation Capacity				-1.415*	-1.529**
				(0.645)	(0.559)
Log(Employees)	0.111	0.143	0.164	0.141	0.162
	(0.181)	(0.178)	(0.169)	(0.177)	(0.167)
Debt in Current Liabilities / Sales	-0.000	-0.001	-0.002	-0.000	-0.001
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
Log(Licensor Number of Patents)	0.042	0.022	0.044	0.037	0.066
	(0.252)	(0.252)	(0.266)	(0.252)	(0.256)
Log(Licensee Number of Patents)	-0.022	-0.015	-0.034	-0.019	-0.039
	(0.029)	(0.031)	(0.029)	(0.032)	(0.029)
Number of Licensed Technologies	-0.024***	-0.022***	-0.020***	-0.021***	-0.018**
	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)
Sub-licensing	-0.143	-0.172	-0.125	-0.144	-0.077
	(0.133)	(0.127)	(0.116)	(0.133)	(0.120)
Exclusive Licensee	-0.105	-0.092	-0.063	-0.133	-0.126
	(0.143)	(0.129)	(0.132)	(0.143)	(0.144)
Grant-Back Clause	-0.176	-0.142	-0.172	-0.160	-0.177
	(0.161)	(0.143)	(0.142)	(0.141)	(0.141)
Technology Age	-0.013	-0.017	-0.017	-0.018	-0.017
	(0.017)	(0.015)	(0.014)	(0.015)	(0.014)
Patent Territory					
US	-0.247	-0.310	-0.351	-0.345	-0.363
	(0.274)	(0.264)	(0.231)	(0.270)	(0.231)
Worldwide (Including US)	-0.340+	-0.352*	-0.378*	-0.363*	-0.396*
	(0.187)	(0.173)	(0.177)	(0.168)	(0.172)
Year Dummy	YES	YES	YES	YES	YES
Constant	1.307	1.441+	1.529*	1.553*	1.587*
	(0.821)	(0.787)	(0.739)	(0.755)	(0.699)
N	334	334	334	334	334
ll	-214.325	-205.674	-194.989	-201.919	-190.470

+ p<0.10, * p<0.05, ** p<0.01, ***p<0.001

Table 3: Logit model with clustered error terms

Dependent variable: Minimum royalty fee	model I	model II	model III	model IV	model V
Technological Proximity		1.343*	1.783**	1.268*	1.721**
		(0.609)	(0.634)	(0.632)	(0.643)
Technological Similarities			-2.162***		-2.144***
			(0.566)		(0.576)
Technological Proximity x Technological Similarities			3.175*		3.411*
			(1.436)		(1.471)
Licensee Assimilation Capacity				0.520	0.164
				(0.675)	(0.666)
Technological Proximity x Assimilation Capacity				1.405	1.565
				(2.224)	(2.108)
Log(Employees)	-0.179	-0.135	-0.164	-0.127	-0.158
	(0.152)	(0.159)	(0.168)	(0.159)	(0.168)
Debt in Current Liabilities / Sales	-0.002	-0.002	-0.004	-0.002	-0.004
	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)
Log(Licensor Number of Patents)	0.306+	0.315	0.402+	0.307	0.395+
	(0.184)	(0.194)	(0.222)	(0.194)	(0.218)
Log(Licensee Number of Patents)	0.044	0.041	0.098	0.033	0.096
	(0.060)	(0.061)	(0.063)	(0.064)	(0.065)
Number of Licensed Technologies	-0.027	-0.026	-0.029	-0.028	-0.029
	(0.027)	(0.026)	(0.027)	(0.026)	(0.027)
Sub-licensing	0.389	0.337	0.229	0.339	0.208
	(0.469)	(0.479)	(0.440)	(0.482)	(0.439)
Exclusive Licensee	0.170	0.163	0.099	0.093	0.093
	(0.532)	(0.536)	(0.510)	(0.558)	(0.536)
Grant-Back Clause	-0.339	-0.342	-0.237	-0.277	-0.201
	(0.478)	(0.462)	(0.478)	(0.469)	(0.479)
Technology Age	-0.003	0.008	0.003	0.009	0.003
	(0.039)	(0.039)	(0.040)	(0.039)	(0.040)
Patent Territory					
US	1.076*	1.092+	1.424*	1.139*	1.412*
	(0.545)	(0.560)	(0.574)	(0.573)	(0.598)
Worldwide (Including US)	-0.056	-0.002	0.056	0.007	0.078
	(0.394)	(0.393)	(0.413)	(0.389)	(0.404)
Year Dummy	YES	YES	YES	YES	YES
Constant	0.031	-0.224	-0.702	-0.203	-0.685
	-1.000	-1.026	-1.034	-1.029	-1.034
N	333	333	333	333	333
chi2	35.022	40.007	59.755	47.794	70.324

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

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