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Understanding Licensing Behavior: A Rent Dissipation Lens on NIH, Product Market Competition and Sunk Costs

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Abstract

The potential for rent dissipation has been argued to be the main cause of firms? licensing out behavior being stifled. However, this aspect has been scarcely studied empirically. We draw on rent dissipation arguments, and hypothesize that firms suffering from the not-invented-here (NIH) syndrome, firms in competitive product markets, and firms that have incurred substantial sunk cost are associated with lower rates of technology out-licensing. We also posit that sunk costs negatively moderate the relationship between competition in the licensor?s product market, and licensing rate. We test our hypotheses using a sample of 151 licensors involved in licensing contracts in the U.S. pharmaceutical industry during the period 1984-2004. We find broad support for our theoretical arguments.

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Understanding Licensing Behavior: A Rent Dissipation Lens applied to the Not Invented Here Syndrome, Product Market Competition, and Sunk Costs

ABSTRACT: The potential for rent dissipation has been argued to be the main cause of firms' licensing out behavior being stifled. However, this aspect has been scarcely studied empirically. We draw on rent dissipation arguments, and hypothesize that firms suffering from the not-invented-here (NIH) syndrome, firms in competitive product markets, and firms that have incurred substantial sunk cost are associated with lower rates of technology out-licensing. We also posit that sunk costs negatively moderate the relationship between competition in the licensor's product market, and licensing rate. We test our hypotheses using a sample of 151 licensors involved in licensing contracts in the U.S. pharmaceutical industry during the period 1984-2004. We find broad support for our theoretical arguments.

Keywords: Technology Licensing, Rent Dissipation, Not-invested-here Syndrome, Product Market Competition, Sunk Costs

1. INTRODUCTION

There has been an upsurge in technology licensing in recent decades (Ceccagnoli & Jiang, 2013; Hagedoorn, 2002; Somaya, Kim, & Vonortas, 2011) in part because technology licensing has come to be recognized as a form of partnership that offers potential major gains for both licensee and licensor. In-licensing can increase the combinatorial potential of licensees (Lowe & Taylor, 1999), realize complementarities (Cassiman & Veugelers, 2006), speed up the invention process (Leone & Reichstein, 2012) and extend the licensee's breadth of technological exploration (Laursen, Leone, & Torrisi, 2010). Out-licensing can generate additional revenues for the licensor (Gambardella, Giuri, & Luzzi, 2007; Katz & Shapiro, 1985; Sakakibara, 2010), boost demand for its technology (Shepard, 1987), appropriate value from the licensee's investment in the licensed technology (Ahuja, Lampert, & Novelli, 2012), and represent reaction to strategic incentives (Ahuja et al., 2012; Ceccagnoli, 2009). However, technology licensing contains substantial growth potential choked only because many firms remain reluctant towards out-licensing their technologies.

The potential for rent dissipation is one of the main reasons for firms stifled out-licensing behavior. In the technology licensing literature, rent dissipation refers to loss of market share, or reduced price cost margins caused by increased market competition through technology out-licensing (Arora & Fosfuri, 2003; Arora & Gambardella, 2010). In giving access to a technology developed internally, the firm may be providing access to intellectual assets that allow the licensee (or other firms partnering with the licensee) to move into or strengthen its position in the licensor's market(s). At the extreme, the licensor may lose the control of the licensed technology and become dependent on the licensee for generating revenue (Fosfuri, 2006). For these reasons, many potential technology-licensing opportunities are not exploited despite the significant potential for benefits.

Few papers investigate the rent dissipation effects in a technology-licensing context. Arora and Fosfuri (2003) suggest that firms with downstream assets weigh rent dissipation against potential revenues from a licensing deal when deciding whether or not to license out a technology. Their study indicates that licensing-out may allow firms to increase their share of industry profits while imposing negative externalities upon other incumbents operating in the same product market. More recent evidence suggests also that high heterogeneity among firms within the same industry reduces the extent to which licensors will experience rent dissipation

(Gambardella & Giarratana, 2012). To our knowledge, only Fosfuri (2006) investigates empirically the way that rent dissipation may be associated with firms' licensing behavior. The rent dissipation effect is weighted less than licensing revenues when competition in the market for technology increases. This results in more aggressive licensing behavior.

In this paper, we argue that technology, market, and investment related circumstances are central for understanding firms' technology licensing behavior. Specifically, we argue that firms suffering from the not-invented-here (NIH) syndrome, firms in competitive product markets, and firms that have incurred substantial sunk cost investments will display less aggressive technology out-licensing behavior. We propose also that sunk costs negatively moderate the relationship between competition in the licensor's product market, and licensing rate. Our arguments draw mainly on the literature on the rent dissipation effects related to technology licensing.

Investigating the role of potential rent dissipation effects on firms' licensing behavior requires comprehensive data on technology licensing combined with longitudinal data on technology and firm conditions. Such data are not readily available which perhaps is the reason for the scarce studies on this important question. In order to test our hypotheses empirically we combine three databases. We start by relying on a sample of 151 firms drawn from the Deloitte Recap database, for the period 1984-2004. We extract the technology licensing contracts related to these firms to create a panel showing each licensor's yearly licensing activity. We supplement this information on firms' licensing activities with data from COMPUSTAT and the United States Patent and Trademark Office (USPTO). Our hypotheses are tested in a longitudinal setting using both negative binomial and logit models with firm and year fixed effects.

The empirical analysis provides overall support for the hypotheses, suggesting that increasing levels of Not invented here Syndrome, Market competition and Sunk costs lead to a decrease in the licensing rates of the firms in our sample. We found evidence also that increasing sunk costs strengthen the negative effect of product market competition on firm licensing rates.

The paper is organized as follows. Section 2 presents the theoretical arguments and hypotheses. Section 3 describes the databases used in this study, calculation of the dependent and independent variables, and the econometric technique used to estimate our models. Section 4 presents the results and section 5 provides a discussion and some conclusions.

2. THEORETICAL BACKGROUND

During the last few years substantial changes have been observed in the way firms organize their activities related to the production of new technologies (Cassiman & Veugelers, 2006). Given the strong competition in the product market, shorter product life cycles, and increased use of information and communication technologies, firms are tending towards business models that allow greater strategic flexibility (Chesbrough, 2003). As a result, licensing agreements have increased dramatically in importance and volume (Anand & Khanna, 2000a; Ceccagnoli & Jiang, 2013; Somaya et al., 2011), and represent one of the most important options for the transfer of technology (Anand & Khanna, 2000b).

Technology licensing contracts are agreements between firms through which the owner of the technology (licensor), in exchange for economic compensation, allows the contractual partner (licensee) to make, sell, and use a technology without transferring ownership (Granstrand, 1999). Surveys conducted by Gambardella, Giuri, and Luzzi (2007) and Zuniga and Guellec (2009) show that the revenue generated in fixed fee(s) and/or the royalties is one of the main motivations for licensing out technology (Sakakibara, 2010). However, licensing out of a technology can also result in a reduction in the licensor's market share or price cost margin as a result of the additional competition in the product market (Fosfuri, 2006). This reduction in the licensor's market share caused by increased competition is described as the rent dissipation effect. Several studies examine questions related to the revenue generated from technology licensing (e.g., Choi, 2002; Sakakibara, 2010; Wang, 1998). However, empirical research on the role of rent dissipation is scarce.

In what follows, we develop hypotheses concerning the association between technology licensing behavior on the one side, and technology, product market, and investment related circumstances on the other. Specifically, we propose testable hypotheses relating licensing behavior to firms' suffering from the NIH syndrome, product market competition, and magnitude of sunk their sunk costs. We draw on rent dissipation related arguments to formulate our hypotheses.

2.1. Hypothesis Development

The NIH Syndrome

The term NIH Syndrome was coined by Katz and Allen (1982: 7) to describe “the tendency of a project group of stable composition to believe it possesses a monopoly of knowledge of its field, which leads it to reject new ideas from outsiders to the likely detriment of its performance”. A well known example of the NIH syndrome is the case of Apple Computers which rejected numerous promising ideas simply because they had been developed outside the firm’s boundaries. Simon (1991) suggests that the NIH syndrome can lead to many reinventions of the wheel. The NIH syndrome can lead firms to dedicate resources to less promising research projects, and ultimately to fall behind in the technology race. Several studies refer to the effect of the NIH syndrome on the demand side of the market for technology (Arora & Gambardella, 2010) but how it affects the supply side of markets remains poorly understood.

There are four arguments suggesting that firms suffering from the NIH syndrome may exhibit less aggressive licensing-out behavior. First, licensing-out may be a means through which firms outsource the further development of their technology to an outsider, capturing advances through contractual specifications such as grant-back clauses (Choi, 2002; Laursen, Leone, Moreira, & Reichstein, 2014; Leone & Reichstein, 2012). The motive for licensing-out may be to leverage the resources of external partners to obtain competitive advantage in the technology (Ahuja et al., 2012). However, firms suffering from the NIH syndrome do not consider this an option since their sense of superiority in the technology causes them not to consider this motive for out-licensing their technological assets which then hampers their technology licensing behavior. This is supported by what Cohen and Levinthal (1990) refer to as increased efficiency in internal communication promoting inward absorptive capacity but also perhaps decreased ability to absorb external knowledge. These firms may be much less inclined to out-license since they are not equipped to reap the associated potential innovation advantages - in which case the dissipation effects are more likely to exceed the potential gains.

Second, the view that internal knowledge and capabilities are superior may cause firms to these assets as core to their business. Indeed, for some firms, technology or technological assets may be a core competence that allows them to compete efficiently in the market (see e.g. Patel & Pavitt, 1997). The NIH syndrome may cause firms to be pre-occupied with their own technology and to consider their technology the core competence. Glorifying own technology can result in firm overestimating the rent dissipation effect, and thus inhibiting its licensing behavior.

Third, the NIH syndrome causes firms to be preoccupied with internal capabilities resulting in technological advances being built mainly on their own technology (Agrawal, Cockburn, & Rosell, 2009). The firm's prior technological achievement may be embedded in their new technologies making them even more vulnerable to the dissipation effect if the new technology is out-licensed. They not only risk potential dissipation caused by signing over the rights to one of their technologies; they also risk rent dissipation on other technologies generated in-house and embedded in the licensed technology.

Fourth, for firms vulnerable to the NIH syndrome, licensing activities may be detrimental to their internal incentive structures. Firms characterized by NIH have been argued to potentially face resistance from their technical staff when pursuing an open innovation strategy (Laursen & Salter, 2006). This may precipitate a negative impact on their core technological activities, and lead in the long run, to an indirect dissipation effect in the product market.

We propose the following hypothesis based on the above arguments:

H1: A stronger NIH syndrome is associated with a lower rate of technology licensing

Product Market Competition

Licensing behavior may be related also to market position (Arora, Fosfuri, & Gambardella, 2001; Fosfuri, 2006). Arora and Fosfuri (2003) propose a theoretical model and argue that licensing, by increasing competition may reduce industry profits, and result in a dissipation effect. However, they argue also that the licensor may experience a revenue effect. Competitors are also affected by the increased competition, which lowers their profits. Due for example to royalty payments, the licensor's profits may be increased by out-licensing in competitive markets. Arora and Fosfuri argue that the revenue effect has a tendency to exceed the dissipation effect in a competitive setting.

There are, however, reasons why product market competition may be associated with less aggressive licensing behavior. First, firms may not consider the potential loss of their competitors when weighing the revenue effect against the dissipation effect. Since this loss is a significant part of the revenue effect, the potential licensor may perceive the revenue effect to be lower than it actually is. This can result in more – and misplaced - reluctance to out-license since the perceived dissipation is seen as exceeding the revenue effect (Arora & Fosfuri, 2003).

Second, it is unlikely that the dissipation effect will be the same for all competitors. The licensor is selling an asset which may create new competitors in the product market, or strengthen the position of an existing competitor (Choi, 2002). The new products introduced by the licensee will be based on the licensor's technology (Leone & Reichstein, 2012) with the result that these products will likely resemble the licensor's products more than those produced by other competitors in the same product market. Thus, for the licensor, the dissipation effect may be much greater than the potential gain; the licensor may experience reduced profit and the dissipation effect is likely to exceed the revenue effect. Only at the unlikely extreme where products are perfectly substitutes would losses in revenue be equal across all competitors in the product market.

Higher product market competition is likely also to cause firms to give more weight to the dissipation effect. Operating in more competitive product markets puts greater strain on firms' profit margins leaving less room for maneuver. Firms will be more aware of profit margins, and will avoid strategies that might threaten their profits further. Accordingly, firms will only license out their technology if the contract specification provides a handsome reward (Choi, 2002). However, this will lower the number of potential licensees, and may make a match in the market for technology unlikely.

Finally, increased competition is associated with a greater shift in market share (Baldwin & Gorecki, 1998; Caves & Porter, 1977; Hymer & Pashigian, 1962). The distribution of market share is less rigid if the product market is more competitive. Therefore, the dissipation effect may be lower in less competitive product markets with more stable market share. In less competitive markets it is more difficult to capture the market shares of incumbents/competitors. Under these conditions, firms may perceive the revenue effect to exceed the dissipation effect and favor out-licensing.

We hypothesize that:

H2: Higher product market competition is associated with lower rates of technology licensing

Sunk Cost

Firms may be subject to sunk costs which are those costs which once incurred, cannot be recovered. Traditional economics argues that rational firms should not let sunk costs affect their behavior. However, due to loss aversiveness and framing effects irrational behavior can occur where decisions are based on already incurred sunk cost (Tversky & Kahneman, 1981). Firms that have incurred large sunk costs may be reluctant to out-license on the basis that they have more to lose. The dissipation effect may be a stronger threat to firms with higher sunk costs making them more reluctant to out-license. For firms operating in very competitive product markets, aversion to loss may be even higher since potential loss in the form of possible exit may appear more imminent, and hence more threatening.

Investments in sunk cost may also signal the pursuit of a strategy to build entry barriers (Dixit, 1979; Porter, 2008). Firms may use their investments to signal commitment. This signal will be even stronger if this investment is a sunk cost. Other firms may interpret this as a sign of poor profitability in the product market. Thus, the number of potential licensees may be lower if the firm has incurred sunk costs and it may be difficult to license out the technology. This effect may be stronger in product markets characterized by intense competition, since both incumbents and fringe firms will expect lower profit margins from the outset.

Based on the above we propose:

H3: Higher sunk costs are associated with lower rates of technology licensing by the firm.

H4: Sunk costs negatively moderate the association between product market competition and the rate of technology licensing.

3. DATA, VARIABLES & METHODOLOGY

3.1. Sample selection and data

The research setting for this study is the global pharmaceutical industry. Several characteristics of the pharmaceutical industry make it a useful empirical setting for testing the relationship between the rate of technology licensing and our variables of interest. First, licensing is one of the most frequent methods of technology transfer among pharmaceutical companies. Therefore, we have an empirical context in which licensing contracts are not restricted to a small number of firms but are used widely as a knowledge transfer mechanism. Second, the pharmaceutical industry is characterized as technology driven and research intensive which makes technological knowledge critical for developing and sustaining competitive advantage (Roberts, 1999). Those characteristics correspond to an industry where the markets for technology are well developed and less hostile which facilitates technology transactions via licensing contracts. Focusing on the pharmaceutical industry represents a tradeoff between generalizability and exactness of estimates. However, given the scarcity of empirical evidence on this topic we believe the purposeful choice of this industry to be appropriate in order to shed light on an important aspect of technology licensing.

The data used to develop the empirical analysis come from three different sources. First, we used the Deloitte Recap Database to obtain a sample of licensors and their contract activities during the 21 year period 1984-2004. The Recap database is one of the most accurate sources of information regarding partnerships in the pharmaceutical industry (Audretsch & Feldman, 2003; Schilling, 2009). It also provides access to the original licensing contracts, allowing us to extract precise information regarding the nature of the licensing contracts, the name of the licensor, and the date the contract was signed. Second, we extracted financial information on licensors from the Compustat database. Third, we obtained information on the patenting activity of licensors from the National Bureau of Economic Research (NBER) patent database.

The hypotheses require us to track financial information for licensors over time. Therefore, we focus on public firms which are listed in Compustat. This restriction reduces the possibility of missing unreported licensing activity. Recap is compiled based on press releases, Securities and Exchange Commission (SEC) contracts, analysts' reports, clinical trials, and requests under the Freedom of Information Act (FOIA), and provides extensive coverage of the activities of large pharmaceutical firms. These sources provide extensive coverage of the pharmaceutical firms listed on Compustat, reducing concern over unreported contracts.

First, we extracted licensing deals reported in RECAP and identified 279 unique public licensors involved in at least one licensing deal in the period 1984-2004. We considered only licensing deals between firms, not between firms and universities for example. The few contracts where the licensee is a university are likely to be associated with a different decision pattern since a university partner is unlikely to cause a potential rent dissipation problem. We also excluded observations regarding amendments and restatements of existing contracts since they likely reflect the decision patterns of the original contracts, and their inclusion would result in double counting of the original contract. Although RECAP focuses primarily on contracts between pharmaceutical firms, it is possible to identify deals with firms operating in other segments. In order to focus only on pharmaceutical firms we extracted from RECAP firms operating in one of the following main four-digit SIC codes: 28- (2833, 2834, 2835, and 2836) and 38- (3826, 3841, 3842, and 3844).[1] Confining the analysis to firms operating in a restricted number of SIC codes reduces concern about cross-firm differences in licensing rates, caused by industry level characteristics in licensing activities and practices.

We used this initial sample of 279 unique licensors to create a panel dataset drawing on information from Compustat for 1984-2004. This final dataset is unbalanced since not all financial information is available for all years for all firms. We observe 171 firms for which all the financial variables of interest were available for at least four periods. We decided to exclude firms with no financial information available for least four years to avoid bias originating from excessive imbalance in the panel structure (Verbeek & Nijman, 1992). This resulted in a total of 1,645 firm-year observations, with an average of 10.8 observations per firm (min= 4, max=20). This information was then lined to RECAP in order to obtain the total number of licensing contracts that licensors had been involved in, in each year.

After linking these databases at the licensor-year level, we observe that the minimum number of licensing contracts in which a licensors was involved in a given year is zero, and the maximum is four. Considering all the years covered in the paper, we observe that around 52% of the firms in the sample out-licensed at least twice. The total number of licensing contracts observed during the period covered by the data is 277, with approximately 18% of the year-firm observations different from zero. We then used the Compustat firm identifier (GVKEY) to connect the licensors in the sample with the NBER U.S. patent data file. To ensure accurate matches we manually checked each individual GVKEY match between the Compustat and NBER datasets. Connecting those two databases allowed us to access licensors' patenting activity over time.

The final dataset includes 1,625 licensor-year observations covering 151 firms tracked over the period 1984-2004.

[1] The four-digit SIC codes cover the following segments: 2833- Medicinal Chemicals & Botanical Products, 2834- Pharmaceutical Preparations; 2835- In Vitro & In Vivo Diagnostic Substances; 2836- Biological Products, (No Diagnostic Substances); 3826- Laboratory Analytical Instruments; 3841- Orthopedic, Prosthetic & Surgical Appliances & Supplies, 3842- Orthopedic, Prosthetic & Surgical Appliances & Supplies, 3844- X-Ray Apparatus & Tubes & Related Irradiation Apparatus.

3.2. Measures

3.2.1. Dependent Variable

Rate of technology licensing

We measure the dependent variable in two different ways. First, in order to test our hypothesis concerning firms´ licensing behavior we tracked the number of licensing deals that licensor j has been involved in (i.e., licensed-out) in a given year t. In other words, this variable represents the count of the number of licensing contracts, which we observe for a licensor in a given year. Considering the panel structure of our data, this variable allows us to observe changes in the number of licensing deals that a licensor engages in, in a longitudinal perspective. This dependent variable is similar to the one used by Fosfuri (2006) but we extend that model by exploring the longitudinal dimension of firms' licensing activity. Second, we computed a dependent variable based on a dummy that takes the value 1 if a licensor j was involved in at least one licensing contract in a given year t, and zero otherwise. The rationale for this second dependent variable is to confirm whether our covariates also explain the licensor's decision to operate in the markets for technology in a particular year.

3.2.2. Independent Variables

Not Invented Here Syndrome

The NIH syndrome is conceptualized as the systematic rejection of ideas generated outside the firm's boundaries (Katz & Allen, 1982). As a consequence, firms with high levels of NIH syndrome are significantly more likely to build on in-house knowledge to create new technologies (Agrawal et al., 2009). Despite the fact that NIH syndrome has been debated intensively in the innovation management literature, little attention has been devoted to operationalizing this construct empirically. In this paper, we employ a measure proposed by Agrawal Cockburn, and Rosell (2009) which was intended to capture firm's myopic behavior related to sources of knowledge. This measured is computed on the basis of backward citations to firms' patents. Patent citations are used frequently as an indication of built-upon knowledge on which firms rely to produce innovations (Novelli, 2014). Accordingly, we calculate this measure in the following way:

$$\text{NIH Syndrome}_{\text{it}} = \frac{C_{it}^{s}}{C_{it}}$$

where C_{it}^{s} represents the total number citations that firm i made to its own patents, and C_{it}, the total number of citations, regardless of the ownership of the cited patent. Following previous studies we use a seven-year moving window to account for knowledge depreciation over time. We believe the measure captures NIH syndrome rather than myopia since it considers the tendency for firms to look inwards. Myopia does not necessarily refer to inward looking tendencies.

Product market competition

Industrial organization suggests that more concentrated industries are characterized by lower levels of competition. Based on this, we operationalize product market competition with a Herfindahl-Hirschman index (HHI) calculated using firm sales data. We use financial information reported in COMPUSTAT to identify all firms operating in the same primary four-digit SIC code in a given year t. Four digits is the lowest level of aggregation we are able to identify. The lowest level of aggregation provides the greatest accuracy for capturing the product market and identifying the licensor's closest competitors. The measure takes account of the sales of all firms operating in the same industry, regardless of their inclusion or not in our licensing sample. The HHI index is calculated using the sum of an industry's squared market share according to the following formula:

$$\text{Product market competition}_{j} = 1 - \sum_{i=1}^{I} S_{ij}^{2}$$

where S_{ij} is the market share of firm i in industry j. We perform the above calculations each year for each industry, and attach the resulting measure to the licensors. This measure has been used extensively in previous studies (e.g., Hou & Robinson, 2006; Lang & Stulz, 1992) to measure the effect of product market competition on several dimensions of firms behavior. Since we are interested in the effect of increased competition on licensing rates, we subtract the original index from 1.

Sunk Costs

Similar to previous studies (e.g., Henisz, 2000; Karuna, 2007; Lambson & Jensen, 1998), we compute a proxy for the licensor's level of sunk costs based on the firm's balance of property, plant and equipment yearly values reported in COMPUSTAT. To avoid capturing size effects, we normalize this measure dividing it by the value of the firm's total assets in the same year. Although this proxy may not perfectly distinguish the degree of disposability among the licensor's different types of assets, the pharmaceutical and biotechnology industries have been reported to be characterized by a high degree of resources specialization (Rothaermel & Hill, 2005) which can significantly reduce firms' capacity to dispose of prior investments related to fixed assets (i.e., property, plant, and equipment). Therefore, we believe that this is a reliable proxy to empirically measure how increasing levels of licensor's sunk costs can affect licensing rate.

3.2.3. Control Variables

Firm Size

The literature on the markets for technology shows that firm size is an important predictor of licensing behavior (Fosfuri, 2006). Larger firms are expected to be more likely to possess both downstream assets related to the licensed technology, and a larger share in the product market. Consequently, larger firms are more likely to experience rent dissipation as a consequence of technology licensing. Therefore, we control for firm size using the logarithm of total sales reported by the licensor j at year t in COMPUSTAT. In line with previous studies we expect that this variable will be negatively correlated with licensing rate.

Number of Firms

Another important control variable is the number of firms operating in the same four-digit SIC code as the licensor j at year t. This variable is aimed at capturing two potential effects. On the one hand, a larger number of firms operating in the same product market suggests a larger number of potential licensees, creating demand for the technologies possessed by the technology holder (i.e., licensor). Also, a high number of potential licensees increases the licensor's bargaining power, creating opportunities for larger revenue effects and making licensing a more attractive alternative vis-à-vis in-house exploitation (Fosfuri, 2006). On the other hand, technology markets are characterized by high search costs (Contractor & Sagafi-Nejad, 1981) which can make the search for suitable licensees a long and costly process. For these reasons, we expect that a larger number of firms operating within the same product market will increase the rate of technology licensing.

R&D Intensity

We control for licensor's R&D intensity by including the R&D expenditures incurred by the licensor j at year t divided by its reported total sales in the same period. We expect that licensors with higher levels of R&D intensity will be more likely to engage actively in technology licensing. Indeed, firms at the forefront of new technological developments are both more likely to possess valuable technologies to license-out and less susceptible to suffering rent dissipation caused by licensees with more technological capabilities and ability to further develop a specific technology (Choi, 2002).

Patent Stock

We control for the licensor's patent stock by computing the total number of patents accumulated by the licensor in the six years prior to the focal year. Our expectations are that firms with a larger number of potential technologies to license out will be more likely to present a higher rate of technology licensing. According to Arora and Ceccagnoli (2006) patenting is a critical requirement for firms in the markets for technology to act as licensors.

Previous Year Licensing

Because firms' current licensing behavior could also be strongly affected by previous licensing experience, we control for the total number of licensing contracts in which licensor j has engaged, one period prior to the focal year.

Market Growth

This variable is intended to capture the rate of growth in the licensor's product market. It is computed based on the relative change in the licensor's product market. We compute the size of the product market based on total sales reported by firms operating in the same four-digit SIC code as the licensor. We calculate market growth based on the following formula:

$$\text{Market Growth} = \text{Market Size}_{t} - \text{Market Size}_{t-1} / \text{Market Size}_{t-1}$$

We expect that as the product market increases, firms will be more likely to increase their technology licensing rates. We expect that an expansion in the product market will make licensors and licensees less likely to compete in the same segments, thereby reducing the possibility of rent dissipation.

There are also several time invariant characteristics related to licensors that need to be included in our empirical model. Previous work shows that firms' licensing behavior in the markets for technology can be affected by fixed factors such as geographic location, operating sector, and other characteristics that remain stable overtime. To reduce the chance of omitted variable bias from stable firm characteristics, we run our analysis using firm fixed effects at licensor level. We use year dummies to capture overall temporal trends in licensing rates. Those specifications are applied in the models used to estimate our two different dependent variables. Finally, in order to reduce concern over simultaneity between our two dependent and the independent variable, we apply a one-year lag to the following variables: Not invented here syndrome, Product market competition, Sunk costs, Firm size, Number of firms, R&D intensity and Market growth. As mentioned earlier, the other variables are computed using different moving windows.

3.3. Econometric analysis and model choice

Since we employ different dependent variables, we propose two distinct models. First, since the number of deals engaged in by a licensor in a given year follows a count distribution taking non-negative integer values and a high number of zeros, we model this dependent variable using a conditional negative binomial regression. The conditional negative binomial specification (Hausman, Hall, & Griliches, 1984) is a generalization of the Poisson which is appropriate under conditions of overdispersion that are likely to apply to our data. As already mentioned, we choose firm-fixed effects to allow for arbitrary correlation between unobserved time-constant factors and the explanatory variables (Wooldridge, 2012). Although the use of fixed-effects estimators removes both desirable and undesirable variation across subjects (Angrist & Pischke, 2009), failing to control for unobserved heterogeneity might result in significant specification errors (Heckman, 1979). Given that the other dependent variable concerns a dummy indicating those licensors that engaged in at least one licensing deal in a given year, we use a logistic model that incorporates licensor fixed-effects.

4. RESULTS

Table 1 reports the means, standard deviations, and Pearson correlation coefficients of the variables used in the fixed effects model. The correlation does not warrant further examination with respect to multicollinearity. We observe moderate correlation between Patent stock and the Logarithm of sales of the order of 0.63, and between Licensor market-share and Logarithm of sales (0.47). Although those correlations are as expected and do not affect our main independent variables, we test the stability of the model coefficients by entering them separately. The main results remained unchanged.

[Insert Table 1 around here]

Table 2 reports the results for the negative binomial and logit fixed models. The dependent variable in Models 1 to 4 is the count of the number of licensing deals in which a licensor has been involved in a given year, represented by a dummy variable that takes the value 1 if the licensor has been involved in at least one licensing deal in a given year, and 0 otherwise (models 5 to 8). The same independent variables are used to test both dependent variables and are entered into the regression step-wise. Model 1s and 5 include the control variables plus the variable capturing licensor's level of NIH syndrome. Models 2 and 6 include the variable Product market competition. Models 3 and 7 include the variable Sunk costs. Finally, Models 4 and 8 include the interaction between Product market competition and Sunk costs.

Hypothesis 1 predicts that a stronger not-invented-here syndrome is associated with a lower rate of technology licensing. The results in Table 2 indicate that the coefficient of NIH syndrome is negative and significant at the 5% level. This holds regardless of out-licensing activity or not, or the number of out-licensing deals. These results provide strong evidence favoring our first hypothesis. Hypothesis 2, higher product market competition is associated with lower rate of technology licensing is also supported if the number of out-licensing deals is included. In the negative binomial analysis, the estimates are negative and significantly different from zero at the 5% level. The corresponding results in the logit specifications show significance at the 10% level.

The results lend support to Hypothesis 3 regarding the effect of sunk costs on the rates of technology licensing. The results for both models are negative and consistently significant at a 5% maximum level of confidence for the variable Sunk costs. Finally, the interaction term between Product market competition and Sunk costs is negative and statistically significant at 5% for the negative binomial model, and 10% for the logistic model. The results of this interaction term offered support for Hypothesis 4 regarding the moderating effect of sunk costs on the relationship between product market competition and the rate of technology licensing.

[Insert Table 2 around here]

Concerning the control variables, in line with work on the markets for technology we find that larger licensors present lower rates of technology licensing. This effect can be explained by the stronger dissipation effect that licensors should experience as a consequence of increased competition in the downstream product market. Although this is not a new finding, it increases confidence in the validity of our estimators. Another result that is in line with our expectations, is the positive and significant effect of Number of Firms operating in the same four-digit SIC code on the licensing rates of the firms in our sample. This finding supports the idea that increased market size is accompanied by decreased search costs for potential licensees. Finally, although the coefficients are not strongly significant, we find that as the product market grows, licensing rates increase. This result is in line with our expectation that expansion of the licensor's product market decreases the likelihood of rent dissipation.

In order to test whether including the main explanatory variables provides significant improvements to the model fit, we used a log likelihood test to compare unrestricted and restricted models (last three rows in Table 2). Models 1 and 5 are compared against a baseline model including only the control variables. Then we compare each subsequent model with the less restricted, immediately previous model. The likelihood ratio comparison test indicates significant improvements in overall model fit with the inclusion of each of our explanatory variables, for both dependent variables.

Supplementary Analysis

Although our empirical setting is robust to alternative explanations we investigate two potential issues related to our estimates. First, it could be argued that our NIH syndrome measure might be positively correlated with the quality of the innovations produced by the licensors in our sample with the result that licensors are more likely to cite their innovations because of their superior quality, not because of systematic rejection of knowledge generated externally. If that were the case, then our proxy for NIH syndrome proxy would not reflect our theoretical construct accurately. To test this, we tracked NIH syndrome levels for each licensor in our sample, for our period of analysis. Based on average values for this variable, we split the sample between firms with high and low levels of NIH syndrome. We then retrieved licensors' patents granted between 1976 and 2006, and used t-tests to investigate whether the number of forward citations (a proxy for technology value) differs between the two groups. The results indicate the presence of a statistically significant ($0.05<p$) difference between the two groups, with a mean value of total citations received by the patents produced by licensors with low levels of NIH of 8.16, compared to 7.82 for the other group. This finding is in line with our expectations about the negative effect of NIH on the value of licensors' innovations. This pattern is similar if we conduct the analysis excluding self-citations – mean value of 7.12 cites to low NIH firms, and 5.89 cites to high NIH firms). Also, the pairwise correlation between our original NIH syndrome variable and the value of the technologies produced by the licensors is low, of the order of -0.07. Thus, the NIH measure does not measure firms that cite themselves because their patents are core patents for the industry as a whole.

[Insert Table 3 around here]

We ran a second robustness check for whether the inclusion of firm fixed effects in our estimates reduces a substantial part of the variation in the main variables of interest. These variables might be fixed over time, in which case we would be removing much of the variation on which in fact may be central for our investigation. If our variables present low levels of within group variance over time, this might originate either in cross-firm differences, or the existence of abnormal values in our sample. To investigate this, we compare within and between group variance among the variables used to test our hypotheses, using an ANOVA test. Based on Table 3, we observe that much of this variation stems from both within and between group (firms) variance. For some of the variables we observe wide within group variance, probably because we are considering a 20 year period which gives firms space for change. Nevertheless, these pattern suggest that even in the presence of firm fixed effects, there is a substantial degree of variation in the estimates and that estimates do not balance on a knifes edge relying on a few extreme values or exclusively on between-firm variations.

5. DISCUSSION AND CONCLUSIONS

Despite the pecuniary and strategic benefits to licensors of technology licensing, many firms are reluctant to out-license their technology. One of the main reasons for this reluctance to engage in licensing activities is the potential for rent dissipation. Drawing on rent dissipation arguments, we hypothesize that firms suffering from the NIH syndrome, firms in competitive product markets, and firms that have incurred substantial sunk cost will engage less in out-licensing. We propose also that sunk costs negatively moderate the relationship between competition in the licensor's product market, and licensing rate,. This paper is one of the first to offer an empirical investigation of organizational and market circumstances as determinants of firms' licensing-out behavior.

To test the four hypotheses we use a comprehensive dataset based on data drawn from the Deloitte Recap, Compustat, and United States Patent and Trademark Office databases. This dataset allowed us to test our hypotheses in a longitudinal setting using both a negative binomial and a logit model with firm- and year-fixed effects. In line with our hypotheses, the empirical analysis suggests that higher levels of NIH, market competition, and sunk costs are negatively associated with the firm's decision to out-license. We found support also for the negative moderating effect of sunk costs on the main relationship between market competition and licensing-out. These results are robust to different econometric specifications.

Our study contributes to various strands of the literature. First, we contribute to the literature on the markets for technology (Fofuri, 2006) by increasing understanding of the determinants of the rent dissipation effect which has been acknowledged to be one of the main obstacles to developments in the markets for technologies. Our findings should stimulate future research on the rent dissipation effect and how firms use different contractual designs to avoid the potential negative effects associated with technology licensing.

Second, we add to work on the effect of competition in technology markets on the licensing trade-off (Fosfuri, 2006) by investigating product market competition which refers to licensors' loss of market share as a result of competing for customers (Choi, 2002). The rent dissipation effect is related to product market dynamics and is linked only indirectly to technology markets. Third, by examining the effect of the NIH syndrome we contribute to the innovation literature. Previous studies discuss the harmful effect of the NIH syndrome on the in-flow of external knowledge; to the best of our knowledge the present paper is the first to connect this effect to knowledge out-flow. We identify several mechanism through which increasing NIH syndrome effects could reduce firms' willingness to grant access to internally developed technologies. This affects technology licensing as well as other inter-firm knowledge transfer mechanisms (Laursen and Salter, 2006) such as alliances and labor mobility (Cassiman & Veugelers, 2006).

Our findings have some limitations. First, the literature on the markets for technology conceptualizes the dissipation effect as the direct effect of increased competition in the licensor's product market. Following previous studies (Fosfuri, 2006), we use an indirect measure of rent dissipation proxied by the firm's yearly licensing-out rate. Although this is an indirect measure, we believe it is a good indication of the potential dissipation effect that firms might experience. Future studies could adopt an empirical design that accounts for shifts in the licensor's market share as a consequence of technology licensing.

Second, we do not distinguish whether the licensor is an incumbent in the market associated with the licensed technology. The rent dissipation effect should be of less concern to licensors if the licensed technology is not related to their main market. We believe that our empirical strategy addresses this issue by restricting the sample to firms operating in the pharmaceuticals industry, which means that licensing contracts are related only to the exchange of pharmaceutical related technologies, and that both licensor and licensee firms are pharmaceutical companies. Therefore, we expect that the licensing contracts in our sample could potentially result in rent dissipation effects for the licensor.

Finally, our results are not directly generalizable; the pharmaceutical industry is a specific case whose characteristics provide the necessary conditions for a well-functioning market for technology. Despite these limitations we believe that this paper sheds light on important, and relatively unexplored dimensions of the licensing literature. We would encourage future research to explore the contingencies related to the dissipation effect in more detail.

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Table 1. Descriptive Statistics and Correlations Coefficients (N =1.625, groups= 151)

	Variables	Mean	S.D.	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
[1]	Number of Licensing deals	0.199	0.474	1										
[2]	Licensing Decision (Dummy)	0.17	0.376	0.93	1									
[3]	Sunk Costs	0.742	1.149	-0.03	-0.04	1								
[4]	Product Market Competition	0.818	0.175	0.02	0.00	-0.02	1							
[5]	Not Invented here Syndrome	0.195	0.271	-0.07	-0.08	0.05	-0.02	1						
[6]	Log(Sales)	3.757	3.062	0.04	0.02	0.13	0.26	0.01	1					
[7]	Number of Firms	167.737	76.727	0.06	0.05	-0.11	0.52	-0.06	0.12	1				
[8]	R&D Intensity	0.477	0.612	-0.03	-0.02	0.38	0.03	-0.06	-0.3	0.02	1			
[9]	Patent Stock	72.999	147.595	0.09	0.06	0.11	0.23	0.08	0.63	0.14	-0.16	1		
[10]	Previous Year Licensing	0.182	0.46	0.17	0.10	0.00	-0.01	-0.05	0.02	0.02	0.02	0.09	1	
[11]	Market Growth	0.114	0.149	0.04	0.05	-0.07	-0.15	-0.03	-0.02	-0.08	-0.02	-0.03	-0.01	1

	Variables	Mean	S.D.	[6]	[7]	[8]	[9]	[10]	[11]
[6]	Log(Sales)	3.757	3.062	1					
[7]	Number of Firms	167.737	76.727	0.12	1				
[8]	R&D Intensity	0.477	0.612	-0.3	0.02	1			
[9]	Patent Stock	72.999	147.595	0.63	0.14	-0.16	1		
[10]	Previous Year Licensing	0.182	0.46	0.02	0.02	0.02	0.09	1	
[11]	Market Growth	0.114	0.149	-0.02	-0.08	-0.02	-0.03	-0.01	1

Table 2: Longitudinal Analysis of Firms' Licensing Behavior (N=1625 across 152 firms with year fixed effects)

	Negative Binomial with Firm Fixed Effects (count)				**Logit Model with Firm Fixed Effects** (dummy)			
Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Product Market Competition x Sunk Costs				-0.643**				-0.609*
				-0.307				-0.362
Sunk Costs			-0.306**	-0.364***			-0.286**	-0.348**
			-0.131	-0.133			-0.143	-0.147
Product Market Competition		-1.849**	-1.868**	-1.895**		-1.864*	-1.927*	-1.928*
		-0.839	-0.84	-0.839		-0.989	-0.993	-0.995
Not Invented here Syndrome	-0.730**	-0.714**	-0.772**	-0.811**	-0.861**	-0.851**	-0.908**	-0.945**
	-0.363	-0.356	-0.359	-0.36	-0.388	-0.385	-0.389	-0.392
Log(Sales)	-0.197**	-0.201**	-0.195**	-0.203**	-0.258**	-0.255**	-0.249**	-0.255**
	-0.09	-0.089	-0.089	-0.089	-0.103	-0.103	-0.103	-0.103
Number of Firms	0.013***	0.014***	0.014***	0.014***	0.015***	0.016***	0.016***	0.016***
	-0.004	-0.004	-0.004	-0.004	-0.005	-0.005	-0.005	-0.005
R&D Intensity	0.210*	0.221*	0.442***	0.481***	0.257**	0.263**	0.467***	0.507***
	-0.115	-0.115	-0.142	-0.141	-0.124	-0.124	-0.155	-0.155
Patent Stock	0.003***	0.002**	0.002**	0.002**	0.003**	0.002**	0.002**	0.002**
	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
Previous Year Licensing	0.046	0.049	0.042	0.041	-0.084	-0.087	-0.095	-0.096
	-0.099	-0.099	-0.101	-0.101	-0.14	-0.139	-0.14	-0.14
Market Growth	0.822	1.063**	1.051**	1.059**	0.852	1.090*	1.077*	1.084*
	-0.524	-0.526	-0.53	-0.529	-0.578	-0.583	-0.586	-0.586
Constant	-0.587	0.485	0.642	0.752	-	-	-	-
	-1.239	-1.321	-1.326	-1.334	-	-	-	-
Log likelihood	-570.95	-568.518	-565.294	-563.981	-477.8	-476.016	-473.602	-472.701
Chi2	72.561***	74.614***	79.827***	82.362***	85.208***	88.776***	93.604***	95.405***
Likelihood ratio comparison	4.514***	4.864***	6.447***	2.626***	5.453***	3.568***	4.827***	1.802***

* p<0.10, ** p<0.05, *** p<0.01, at a two sided test

Table 3. Analysis of Variance

Variable		Sum of Squares (SS)	Share (%)
Number of Licensing deals	Between groups	40.33	11.06%
	Within groups	324.47	88.94%
	Total	364.80	
Licensing Decision	Between groups	17.43	7.58%
	Within groups	212.36	92.42%
	Total	229.78	
Sunk Costs	Between groups	463.04	22.17%
	Within groups	1625.72	77.83%
	Total	2088.75	
Product Market Competition	Between groups	32.71	65.45%
	Within groups	17.27	34.55%
	Total	49.97	
Not Invented here Syndrome	Between groups	38.05	31.91%
	Within groups	81.20	68.09%
	Total	119.25	