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Financial constraints in Markets for technology:

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Abstract

Albeit the phenomenon is currently widespread, the role of licensing in the financing of innovation has been under-investigated by scholars so far. Anecdotal evidence, instead, suggests that in some circumstances licensors is required to further develop the licensed technology which the licensee may finance by paying an upfront fee. Thus, the need for extra finances may affect the decision of the licensor to negotiate and thus actually agree on a specific form of payment. The aim of our paper is to investigate whether financial constrained licensors are more likely to choose an upfront fee-based license and more inclined to credit a portion of the initial fee against future royalties to meet their short-term financing needs. We investigate this issue by combining the Recombinant Capital's Biotech Alliance (Recap) with Compustat and the USPTO patent database.

Financial constraints in Markets for technology: Licensing as a source of finance

ABSTRACT

Albeit the phenomenon is currently widespread, the role of licensing in the financing of innovation has been under-investigated by scholars so far. Anecdotal evidence, instead, suggests that in some circumstances licensors is required to further develop the licensed technology which the licensee may finance by paying an upfront fee. Thus, the need for extra finances may affect the decision of the licensor to negotiate and thus actually agree on a specific form of payment. The aim of our paper is to investigate whether financial constrained licensors are more likely to choose an upfront fee-based license and more inclined to credit a portion of the initial fee against future royalties to meet their short-term financing needs. We investigate this issue by combining the Recombinant Capital's Biotech Alliance (Recap) with Compustat and the USPTO patent database.

Keywords: Innovation Financing, Licensing, Financial Constraints, Upfront Fee

INTRODUCTION

Markets for technology provide incentives for specialization economies, through the mechanism of the division of innovative labor across organizations (Arora, Fosfuri and Gambardella, 2001). Both large and small firms benefit from a wider range of strategic options available to shape their corporate strategy (Arora et al., 2001; Cesaroni, 2006). On the one hand, large firms could either sell or license out their peripheral technologies or exploit the innovative capacity of specialized firms (e.g. biotech) by acquiring the missing spots of their innovation pipeline. Small firms, on the other hand, can either focus on the improvement of technologies for which they have developed specialized skills and consequently sell or license them out, or rely on other firms' knowledge base to fill the gap of their innovation roadmap.

Sometimes, smaller firms can also exploit markets for technology, and licensing contracts in particular, to get additional financial resources and alleviate financial constraints that inhibit them to make further R&D investments (Kulatilaka and Lin, 2006). Albeit licensing practices have become very popular (Anand et al., 2000; Arora et al., 2001; Athreye et al., 2007; Chesbrough, 2003; Fosfuri, 2006; Gu et al., 2004; Kim et al., 2006), the role of licensing as a source of external finance has been underestimated in the literature of markets for technology. For these reasons, the aim of the paper is to study the financial implications of markets for technology, by focusing on the role of licensing agreements as financial instruments to access external monetary resources.

We propose, in particular, that this type of contract, given its specific economic structure, composed by both fixed and variable payments, which are due either upfront or in deferred dates, can be fruitfully exploited as a surrogate financing source for the licensor firms. The possibility of extracting value from patents through the licensing-out agreements, instead of waiting until product commercialization, allows the licensor to monetize his/her

assets and meet his/her short-term financing needs, especially if the licensing contract embeds a significant upfront fee to be paid by the licensee at the signing of the contract¹. This is particularly important for high-tech firms that suffer from strong financial constraints. Mainly biotech firms, facing problems to access equity and debt markets, are seizing this opportunity by licensing out their earlier-stage clinical programs to big Pharmas, when R&D investment financing is mostly required (Kessel and Hall, 2006).

However, financially constrained licensors might be in an unfavorable negotiating position due to their urgent need for finance and agree on contractual schemes leading to suboptimal outcomes (Kulatilaka and Lin, 2006). This last consideration casts several doubts on the long-term sustainability of licensing-based strategies for financially constrained licensors.

With these considerations in mind, the aim of this paper is to contribute to the literature on the financial constraints of innovative firms by focusing on the role of markets for technology and, more specifically, on the use of licensing as a source of finance. We ask, in particular, the following research questions: do financially constrained licensor prefer licensing contractual schemes with upfront fees? Do they exchange upfront fees with a higher fraction of royalties as compared to non-constrained licensors?

In addressing these questions, we combine the literature on the financial constraints of high tech firms (e.g., Himmelberg and Petersen, 1994) with the theoretical insights of Kulatilaka and Lin (2006), who have elaborated a model analysing the effect of licensing on the financing of technology development under uncertainty. We develop a set of hypotheses to predict the choice of the payment structure of a licensing contract based on the potential

¹ “The payment [upfront fee] is designed to create immediate commitment to the relationship on the part of the licensee. The money is useful to the licensor as it may provide funds for further IP protection, or represent recovery of a portion of R&D costs” (Simon Rowell. 2008. “New Zealand: Strategic Tips For Adding Value To Licensing Transactions”, available at <http://www.mondaq.com/article.asp?articleid=70118>, retrieved on Monday 16th of February).

financing needs of the licensor. Based on a dataset of 316 licensing agreements, we tested if financial constrained licensors are more likely to agree on an upfront payment in the place of future stream of revenues (both fixed and variables) and, in addition, if it will bargain a certain amount of upfront fee according to his financing requirements.

The remainder of this paper is organized as follows. Next section focuses on the development of the hypotheses to be tested drawing from previous theoretical works, empirical contributions and novel insights. Subsequently, the research design is comprehensively illustrated with the description of data, the specification of the econometric technique employed and the definition of the variables included in the analysis. The results are then presented and the paper finalizes with a section dedicated to the discussion and some conclusive remarks.

HYPOTHESES DEVELOPMENT

The problem of innovation financing has received a great deal of attention within the financial literature (e.g., Himmelberg and Petersen, 1994; Guiso, 1998; Carpenter and Petersen, 2002). Several authors have argued that internal finance is the primary source of financing of firms' research and development (R&D) investments (see Hall, 2002 for a review). The reason for this resides in the imperfections of the capital markets (Fazzari et al., 1988), which are exacerbated in case of R&D investments because of the uncertainty about the technology, the non-rival nature of the asset (knowledge) (Nelson, 1959; Arrow 1962) and the existence of information asymmetries – related to the lemons problem (Akerloff, 1970) - between companies and suppliers of external finance (Himmelberg and Petersen, 1994). Under these circumstances, firms face a wedge between the costs of internal and external funds, also called financial constraints (Kaplan and Zingales, 1998), which prevent them to commit to further investments on time and money-consuming research projects,

unless they are endowed by internal resources of capital. This is mostly true for high technology small firms - which are meant to be more innovative and thus spur the innovation progress – which often lack financial resources to carry on R&D projects (Himmelberg and Petersen, 1994; Guiso, 1998; Carpenter and Petersen, 2002; Scellato, 2007).

Some authors have questioned, however, the assumption of the superiority of internal finance, therefore challenging the relative advantage of integrating R&D within large firms, in favour of a widespread diffusion of the division of innovative labour across organizations (e.g. Lerner, 1995). According to this work, the rise of financial intermediaries, especially equity financiers (like venture capitalists, and private equity), which are taking an active role in fuelling capital constrained firms (i.e. hi-tech start-up), indicates that “financial constraints on the division of innovative labour are not insurmountable” per se (Arora et al., 2001). Although the availability of equity finance may provide incentive to firms to specialize and invest in R&D activities, however the match is not immune from failure. First of all, it is difficult to assess the potential value of innovative projects; second, the small amount of interventions required (the so-called “small-ticket problem”, Berger and Udell, 1998), sometimes coupled with the reluctance of entrepreneurs to disclose relevant information to outsiders (Giudici and Paleari, 2000), may prevent achieving a deal; finally equity financiers require a thick stock market (e.g. Nasdaq), which may be absent (Hall and Lerner, 2009), to ensure a profitable exit strategy (i.e. selling the shares of financed firms) of their early stage investments.

In this paper we advance that there is an alternative possibility available to financially constrained firms to raise financial resources. By acting in the markets for technology, they can license out the technology in exchange of monetary resources, partially collected by the licensor as immediate payment in the form of upfront fee. Licensing is particularly suitable as a source of financing for constrained firms for its peculiar structure of payment,

encompassing two main elements: upfront fee and royalties. The former consists of an initial fixed fee which is due at the beginning of the contract, while the latter is a variable payment which is recursively paid as a compensation for the use of the licensed technology during the license agreement typically calculated as a percentage (i.e., royalty rate) of the revenues of the licensee. From the licensor's perspective, the upfront payment represents an immediate way to get financial resources from the counterpart and it is mostly needed anytime the firm has to commit to further investment on the current technology, as in the case he/she faces a fierce competition by other companies, which may undermine his/her technological lead (i.e. deterrence effect, Gallini, 1984).

Besides the remuneration aspect, what makes the licensing agreement appealing as a surrogate for traditional financial sources (equity and debt) is its intrinsic nature of technological partnering. In the licensing context, in effect, the external financier is replaced by the licensee who generally is an industrial firm that by definition has a better knowledge about the licensed technology than any external financial investor, which reduces information asymmetries and transactions costs and makes the transaction easier. The licensee can also share some strategic objectives with the counterpart to ease the negotiation process and improve the chance of a fruitful exploitation of the contract.

Holding these insights together, we can argue financial constraints may affect the decision of the licensor to agree on a specific form of payment within the licensing contract. In particular, a financially constrained licensor would much more be eager to bargain a certain amount of upfront fee, so that the licensing agreement could be used as a form of external financing (Kulatilaka and Lin, 2006). Based on these considerations, we formulate our first hypothesis, as follows:

Hypothesis 1: Financially constrained licensors will be more likely to choose a licensing contractual scheme with an upfront fee

The majority of licensing contracts include both an upfront fee and a variable recursive payment (royalty). The optimal trade-off between the two is the result of a time-consuming negotiation which, in many cases, may cause the agreement to fail, if the parties do not reach a compromise. It is straight forth to figure out that financially constrained licensors have preferences for upfront payments as compared to differed payments, such as royalties. According to the extant literature (e.g. Vishwasrao, 2007), this is mostly true if the licensor is risk-averse, since he/she can hedge against the risk of unsuccessful or opportunistic exploitation of the license by the license firm. Being pre-paid, regardless of the licensee's performance, keeps the licensor safe from the uncertainty associated to the contract. However, the licensee usually has an opposite interest. Albeit variables payments imply a distortion of the marginal costs borne by the licensee, it would generally prefer not to commit to upfront payments, for the uncertainty of the value of the licensed technology in terms of future returns in the market place. According to Bousquet, Cremer, Ivaldi and Wolkowicz (1998), high level of uncertainty justify the inclusion of royalties as a risk-sharing device. In particular, the authors remark that “[u]nder uncertainty, royalties continue to have *an output distortion effect. However, they also provide a measure of insurance. [...] The optimal contract strikes the right balance between the positive and negative effects of royalties*” (Bosquet et al., 1998: 542-543). Therefore, in the game of negotiation, royalties over perform initial payments since they are due only after the real potential of the technology has been revealed. Advancing this argumentation, Vishwasrao, (2007) also suggested that when licensor's reputation is at stake, royalties outperform lump sum payments since the licensor needs an incentive mechanism to ensure that the licensee is committed to the development and commercialization of the licensed technologies.²

² As alternative to royalties, the author suggested that the licensor could decide to have an equity stake on the licensee firm. Equity participation performs the same risk-sharing function as royalties, without the distortion effect. It allows the licensor to control the licensee while providing a stream of revenues in the form of

Although insightful, prior literature, dealing with the optimal contract design of license agreements, does not provide clear indication about the impact of financial constraints on the licensor's preference of a particular form of payment. Indeed, from the licensor's perspective, the critical decision is about the right balance between upfront and future forms of payments which impacts on the amount of monetary resources available to him at the moment of negotiation. Although it is easily arguable that a highly financially constrained licensor would ask for more upfront, this may not be always the actual outcome, given the discussed preference of the licensee for royalty payments. Therefore, if the licensor financially constrained, he might be willing to forego a significant and disproportionate part of the expected royalties to obtain an increment in the amount of upfront fees (Kulatilaka and Lin, 2006). We hence formulate the following hypothesis:

Hypothesis 2: Financially constrained licensors will need to renounce to more royalties to obtain a certain amount of upfront fee as compared to non-constrained licensors (i.e., the sensitivity of the upfront fee to the royalty rate will be lower in absolute terms)

Methodology

Sample

In order to test the proposed hypotheses we rely on a sample of technology licensing contracts between firms operating in the global pharmaceutical industry. Firms in this industry develop and commercialize drugs, biological products, chemical components and medical devices. To empirically identify licensing contracts involving pharmaceutical firms, we limited our sample to deals in which the licensors' main Standard Industrial Classification (SIC) is one of the following: 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 &

dividends accrued to the licensor.

Supplies; 3842- Orthopedic, Prosthetic & Surgical Appliances & Supplies; 3844- X-Ray Apparatus & Tubes & Related Irradiation Apparatus; 3851- Ophthalmic Goods; 8071- Services-Medical Laboratories. Restricting the sample to a limited number of SIC codes alleviates concerns about potential bias originating from cross-industry differences in firms' licensing and contractual practices.

We chose this empirical setting for three main reasons. First, the pharmaceutical industry is characterized as technology-driven and R&D intensive (Roberts, 1999). As a consequence, firms in this industry heavily rely on external sources to access the state-of-the-art in terms of new knowledge. Indeed, pharmaceutical firms commonly use licensing contracts as a mechanism to trade and exchange technologies (Schilling, 2009). As licensing activities in this industry are not restricted to a small group of firms, this context allows us to investigate cross-firms differences in the remuneration structure of contracts as a consequence of financial constraints. Second, previous studies have shown that pharmaceutical firms consider licensing revenues as an important part of their overall strategy to profit from innovation and to manage their drugs development pipeline (Arora and Gambardella, 2010; Ceccagnoli, Higgins and Palermo, 2014). Therefore, this is an appropriate context to the use of technology licensing as a source of finance. Finally, pharmaceutical firms systematically protect and document their inventions through patents (Levin et al., 1987). This way, we are able to use patent information to incorporate in the empirical analysis a set of important variables regarding firms' patenting behaviour.

To select a sample of licensing contracts related to the pharmaceutical industry we relied on the licensing deals listed at the Recombinant Capital Biotech Alliance Database (hereafter Recap) for the period 1984-2004. This database is an accurate and extensive source of information regarding technology commercialization deals involving pharmaceutical firms (Schilling, 2009). A large number of previous studies have used it to investigate different

aspects of technology licensing (e.g., Schilling, 2009; Banerjee, 2012; Ceccagnoli, Higgins and Palermo, 2014). This dataset offers access to original licensing deals, from which we can extract detailed information on the remuneration structure, characteristics of the licensed technology and identification of the firms (i.e., licensor and licensee) involved in each contract.

Although Recap includes several types of contractual arrangements (e.g., research alliances and joint-ventures), in this study we are interested only in technology licensing contracts. Additionally, because our hypotheses concern the effect of financial constraints on the use of upfront payments in licensing contracts, we decided to use in the empirical analysis only public firms. The focus on public firms ensures the access to consistent financial information over different periods of time. Although firms may choose not to report their licensing deals, focusing the analysis on firms which are legally obliged to publicly report on their financial activities reduces the chance of missing unreported licensing deals. Indeed, Recap is compiled based on press releases, Securities and Exchange Commission (SEC) contracts, clinical trials, and requests under the Freedom of Information Act (FOIA). Those sources offer extensive coverage for licensing activities of public pharmaceutical firms.

Finally, we use information from the USPTO (United States Patent and Trademark Office) to access both the patenting activity of the licensors and licensees involved in the deals and characteristics of the licensed technologies. At the licensor and licensee level, we use the information retrieved from the USPTO is used to compute the technological profiles of the firms ex ante licensing by extracting all patents applied in the five years prior to entering a deal. Despite the fact that not all firms make use of patents to protect their inventions, patenting is often a necessary condition for technology licensing (Arora and Ceccagnoli 2006). In fact, it has been shown that, particularly in the pharmaceutical industry, patenting is an important step for firms to profit from licensing contracts (Arora and Gambardella, 2010).

At the technology level, we connected the licensed technologies with USPTO data using the 7-digit patent number regarding each unique technology listed in the licensing contracts.

Those three databases were connected in the following way. We started from Recap database identifying all observations regarding licensing deals which had the licensor operating in your of the SIC codes that we previously mentioned. After that, we remove the contracts involving universities and research institutes as those observations would not be appropriate to test the effects of financial constraints on the payment structure of the contracts. Subsequently, we removed licensing deals which are restatement of existing contracts and only repeat the same contractual structure of the original deal. Then, we also drop out of the sample the observations that, for confidentiality reasons, do not disclose information on the royalty and upfront payments associated with the contract³. On the basis of these restrictions, Recap provides an initial sample of 443 observations at the contract level. In the next step, we used companies name, address, and industry affiliations provided by Recap to connect the licensors with Compustat. During this process, 98 observations were lost regarding the contracts in which the licensor was not a public firm. Finally, we used the company names of both licensor and licensee to connect the remaining observations with USPTO patent data. After connecting those three databases we were left with a sample of 316 contracts to test our hypotheses.

Dependent Variable and Analytical Technique

In order to estimate the determinants of the probability of having a contract with upfront fees and the amount of the upfront fee, our dependent variable is measured in two different ways. First, we consider the likelihood that a contract will included upfront payments. Second, we examined those deals with a positive outcome on the first condition and model the total amount of upfront fee specified in the contract. Accordingly, we start by creating a binary

³ This does not include contracts that have zero royalties or upfront payments

variable coded as one if the contract includes an initial payment sum and zero otherwise. We examined the effect of level of the licensor's financial constraints on this binary outcome using a probit regression with robust standard errors clustered at the licensor level to correct for the heteroskedastic and account for repeated sampling of firms (White, 1980). Subsequently, we operationalize the dependent variable with total amount (non-zero) of upfront payment that the licensee agrees to pay the licensor for having access to the licensed technologies. Given that the fixed amount of upfront fees does not follow a normal distribution, we use natural logarithm to reduce the skewness in the original values. We tested for the effects of our independent variables in this outcome using an ordinary least-squares (OLS) regression, again using robust standard errors clustered at the licensor level.

It is important to note that using this estimation strategy creates potential sample selection bias in our analysis regarding the second equation. This potential bias comes from the fact that contracts having any positive amount of upfront payment maybe systematically different from those for which this amount is zero. When we consider particularly the case of licensor's level of financial constraints, we expect that other unobserved factors affecting the likelihood of using upfront payments could also be related to this main explanatory variable. Also, our estimation strategy must take into account that the errors of both equations can be correlated. To address those concerns, we use the Heckman's two-stage model (Heckman, 1979), which is designed to deal with sample selection by using a correction term, the inverse Mills ration, calculated from the probit model predicting the first stage (likelihood of having up front payment) as a control variable in the analysis of the second-stage (amount of upfront payment). In this way, the error in predicting the probability of having an upfront fee can be correlated with the error in the upfront fee amount equation. The model that we estimate is then written as follows:

$$\begin{aligned}
d_i &= 1(Z_i \delta + \varepsilon_{1i} > 0) \\
y_i &= d_i \cdot (X_i \beta + \varepsilon_{2i}) \\
\begin{pmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{pmatrix} &\sim N \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho\sigma_2 \\ \rho\sigma_2 & \sigma_2^2 \end{pmatrix} \right]
\end{aligned}$$

Where d_i is a dummy equal to one when upfront fee is present and y_i is the variable measuring the amount of the upfront fee. For this model, it can be shown that the regression of y_i on X_i for the observed data has the following form:

$$E[y_i | d_i = 1, X_i] = X_i \beta + E[\varepsilon_{2i} | \varepsilon_{1i} > -Z_i \delta] = X_i \beta + \rho\sigma_2 \lambda(Z_i \delta)$$

Where $\lambda(\cdot)$ is the inverse Mills' ratio for normal distribution. The Heckman two-step estimator for this model involves estimating δ using a Probit equation, forming the λ , and including it in the equation with the other explanatory variables.

In order to provide more robust estimates for the Heckman two-stage model, we use an exclusion restriction in the first-stage selection equation (Cameron and Trivedi, 2009). We base the exclusion restriction on a dummy variable indicating whether the contract regards a cross-licensing deal. This variable is expected to be negatively correlated with the probability of a contract having upfront payments, but not necessarily with the total amount of upfront fees negotiated between the parts. Indeed, cross-licensing contracts are usually signed for strategic reasons, rather than as a source of finance, in such a fashion that technology holders mutually benefit from the other's IP rights related to a certain group of technologies (Andersen and Konzelmann, 2008). In fact, it is not uncommon that cross-licensing contracts are signed as a way to waive the payment of fees that firms would incur in case they would enter into traditional licensing contracts (Andersen and Konzelmann, 2008). Accordingly, we expect that cross-licensing contracts will generate nontrivial variation on the likelihood that a licensing contract will include upfront payments, but the amount observed in

each contract is more likely to be determined by other factors related to technology (e.g., value and uncertainty) or firm characteristics (e.g., size and market power).

Independent Variables

In order to test for the effect of financial constraints on our two dependent variables, we use the ratio between net cash flow and total assets at $t-1$ as a proxy for the licensors' level financial constraints. In doing so, we follow Allayannis and Mozumdar (2004) proposition that firms in financially constrained situations are substantially more likely to exhibit negative cash flow. In order to align our proxy for financial constraints with the same direction of our hypotheses, we rescaled this variable multiplying it by (-1). Therefore, while in the original variable increasing values indicate lower levels of financial constraints, after rescaling the variable increasing values indicate higher levels of financial constraints.

The other independent variable in our analysis regards the royalty rate specified in the licensing contract. The common base for the calculation of the royalties is the annual amount of net sales of the licensed products, with ongoing royalty payments being contingent upon the commercialization performance of the technology in the downstream market (Feldman et al. 2002). The literature on technology licensing indicates that the use of royalty payments is particularly important when the uncertainty related to the future development and commercial exploitation of the licensed technology is high (Choi, 2002). Indeed, royalty payments are fundamental to ensure that the imperfections in the technology market will prevent deals to take place (Caves et al., 1983). Regarding the relationship between royalty payments and upfront fees, it is widely held that royalty rates are negatively correlated to the amount paid upfront in revenue sharing contracts (e.g. Brickley, 2002; Lafontaine, 1992; Lafontaine & Shaw, 1999). This relationship is due to the fact that the expected royalty payments reduce the downstream profits that will accrue to the licensee. As a consequence, the higher the royalty rate, the lower the upfront fee that the licensee will be willing to pay to have access to

the licensor's technologies. In this paper we argue that financially constrained licensor will prefer upfront fees to royalties, so that it will be available to forego more royalties to get cash up front. This means that the upfront fee will be more rigid to changes in the royalty rate, i.e. to obtain a higher upfront, a financially constrained licensor will be available to renounce to a higher percentage of the royalty rate than a non-constrained licensor. We compute fixed royalty rate based on the percentage of the net sales that the licensee agrees to pay to the licensor as a consequence of the commercial exploitation of the licensed technology.

Control Variables

We include several contract-, technology-, and firm-level control variables that may affect the remuneration structure of licensing deals, but are not part of our hypotheses. In relation to contract characteristics, we control for the presence of milestones payments with a binary variable that takes value one if the contract foresees milestone payments and zero otherwise. We also included a dummy variable that takes the value one if the licensing contract includes a granted minimum royalty clause. This clause indicates that the licensor will receive a given minimum royalty independently of the licensee's performance in exploiting the licensed technology (Battersby & Grimes, 2005). Additionally, previous studies have shown the importance of the grant-back clause in shaping learning opportunities and knowledge between licensor and licensee (Choi, 2002; Leone and Reichstein, 2012). As the amount and the nature of the knowledge transferred between the parts in a deal can affect its remuneration structure (Choi, 2002), we added a dummy variable that indicates if the grant-back clause is used. Another important contractual condition is exclusivity. The value of the contract should also differ depending on whether is an exclusive license or not. Exclusive license allows the licensee to exploit the licensed technologies without bearing the competition of other licensees in the market. We control for this effect including a dummy, called exclusive licensee which is equal to 1 if the licensee is exclusive and 0 otherwise. Another relevant

contractual arrangement in licensing deals, regards the grant to the licensee exclusive rights to buy subsequent innovations related to the licensed technology. In order to have such rights licensees are likely to agree to pay larger amounts to the licensor. To control for the use of this contractual specification, we use a dummy variable that takes value 1 if this condition is present in the deal and zero otherwise. Finally, given that some licenses include more than one patent, we include a measure of license scope, herein intended as the number of the patents involved in the deal.

We control also for several technology characteristics⁴. The initial amount of payment agreed between parties depends on the value that the licensed technology has to the licensor. As previous studies on patent data (e.g., Trajtenberg, 1990) have shown that the value of a patent can be proxied by the number of forward citations that it receives, we control for the number of *licensor's citations* to the licensed patents until date of the deal. Because the number of citations to specific technology may fail to capture the extent to which the licensed technology lies in a core technological area to the licensor, we also included an additional control to capture the degree of overlap between the technological class of the licensed technology and the licensor's portfolio. We do it by employing the "focal index" proposed by Ziedonis (2007), which is measured as follows:

$$Licensor\ Core\ Technology = 1 - \left[\frac{\left(\sum_{t-5}^t \sum_j \tilde{c}_i \cdot \rho_i \right)_c}{\left(\sum_{t-5}^t \sum_j \tilde{c}_i \cdot \rho_i \right)} \right]$$

where $\left(\sum_{t-5}^t \sum_j \tilde{c}_i \cdot \rho_i \right)_c$ represents the citation-weighted sum of firm i's patents which were applied for within five years of the time of the license agreement t and which belong to the same primary patent class c as the licensed patent; and $\left(\sum_{t-5}^t \sum_j \tilde{c}_i \cdot \rho_i \right)$ is the sum of all

⁴ For the contracts which have more than one patent, the calculations related variables related patents are based on mean values

citation-weighted patents issued to firm j that were applied for by date t during the same five-year time window.

Another important aspect of the licensing deals regards the stage of development of the licensed technology. Particularly in the context of the pharma industry, it is important to account for the effect that the stage of development at which technologies are being licensed has on the remuneration of the contracts. Based on Recap information, we create a dummy variable called early stage technology, taking value one if the drugs have been licensed from the discovery to the preclinical stage⁵. Finally, each contract in our sample is associated with a main therapeutic class; we rely on the classification proposed by World Health Organization to create dummy variables that account for differences in terms of twelve therapeutic classes⁶ observed across the licensing deals.

The last set of control variables regards firm characteristics. Given that larger licensors may have more bargain power to negotiate favourable remuneration conditions, we control for licensor size using the logarithm of current assets at the year prior to the licensing deal. We also control for licensor's R&D intensity as total R&D expenditure divided by total assets also at $t-1$. In order to control for the licensor's financial leverage, we include in our model the solvency ratio which is calculated by dividing the licensor liabilities by total assets also at $t-1$. We added to the model a dummy variable that takes the value 1 if the licensor is headquartered in the United States. In order to account for heterogeneity at the licensee side, we included the licensee's patent stock as a proxy for size. We operationalized *licensee's* patent stock using the log of the total number of patents that the licensee successfully filled in

⁵ The possible stages at which a drug can be licensed are Discovery, Lead Molecule, Preclinical, Phase I, Phase II, Phase III, Approved, BLA/NDA Filed and Formulation

⁶ These therapeutic classes are: (A) alimentary tract and metabolism; (B) blood and blood forming organs; (C) cardiovascular system; (D) dermatologicals; (G) genitourinary system and sex hormones; (H) systemic hormonal preparations, excl. sex hormones and insulins; (J) anti-infectives for systemic use; (L) antineoplastic and immunomodulating agents; (M) musculoskeletal system; (N) nervous system; (P) antiparasitic products, insecticides, and repellents; and (R) respiratory system.

the eight years prior to the licensing deal. In order to capture variations in the dependent variable caused by the market proximity between licensor and licensee we generated a dummy variable that takes value 1 when both firms operate in the same sector and 0 otherwise⁷.

Finally, following the standard practices, we included in our analysis year fixed effects based on the year that the licensing contract was signed and industry fixed effects based on the licensor's main SIC codes described earlier in this paper.

RESULTS

Based on the full sample of licensing contracts (N=316), Table 1 reports descriptive statistics and pairwise correlation coefficients among the independent variables. With the exception of R&D intensity and Financial constraints with a correlation of 0.86, the other coefficients raise no concerns regarding multicollinearity. We checked for potential bias regarding the high correlation among those two independent variables entering them in the model separately. Given that the effect of Financial constraints on the dependent variables remained the same when we remove or not R&D intensity, we concluded that despite the high correlation our results are not biased in this regard (see model 5 and 10 in Table 2). Furthermore, we investigate potential collinearity issues beyond pairs of variables using the maximum variance inflation factor (VIF) statistics. The results indicate that the maximum VIF associated with any of the independent variables is 5.52 (mean VIF=2.05), which is well below the rule-of-thumb value of 10 (Gujarati, 1995).

[Insert Table 1 around here]

We also examined if the correlation among the independent variables are in line with our expectations. As expected, we see that licensor size is negatively correlated with financial

⁷ Based on Recap information we classified firms in the sample based on three operating segments: Pharma, biotech and medical devices

constraints (-0.66), indicating that smaller firms are more likely to experience cash constraints. In line with this finding, Table 1 also indicates that financially constrained licensors are more likely to license-out core technologies. Not surprisingly, we also see a moderate correlation (0.28) between the amount of royalty rates in a licensing contract and the likelihood that the deal regards an exclusive licensee. This suggests that if the licensing contract is going to rule out licensor's possibility to increase profits by licensing the same technology to multiple licensees; it is more the licensor will look for more favorable remuneration conditions. Finally, we also observe a negative correlation (-0.10) between the likelihood that the licensee will have exclusive rights to buy future improvements on the licensed technology and early stage technologies. Indeed, licensors are expected to be more reluctant to grant the access to future improvement on technologies which have high levels of uncertainty.

Table 2 reports the results for the Heckman's two-stage model with robust standard errors clustered at the licensors. The first five models (1, 2, 3, 4 and 5) report the results for the first-stage analysis, in which the dependent variable is the likelihood that a contract will include upfront payments. Based on the full sample of 316 contracts, we observe that 207 include upfront payments. Model 1 includes only the control variables, presenting several statistically significant effects: cross-licensing ($p < 0.01$), milestones ($p < 0.01$), minimum royalty ($p < 0.05$) and license scope ($p < 0.10$). Considering particularly the coefficient for cross-licensing, which remain consistently negative and highly significant across the all the models, we find evidence that the one of the condition for the exclusion restriction regarding the non-triviality of the instrument in the first stage was met.

[Insert Table 2 around here]

Model 2 adds the main effect used to test our first hypothesis regarding the inclusion of upfront payment in licensing contracts as a consequence of the licensor's financial

constraints. As the coefficient for the variable financial constraint remains positive and significance at a minimum of 5% in all the models in the first stage, we find evidences in the direction of hypothesis 1. Accordingly, in line with our expectations we find that as the level of licensor's financial constraints increase, it becomes more likely that technologies will be licensed under a contract with upfront payments.

In the second stage of analysis, our models (6, 7, 8, 9 and 10) examine the effect of the explanatory variables on the amount of upfront payment in licensing deals selected with a positive outcome in the first stage (N=207). Those models include the Inverse Mills ratio as a control for sample selection bias (Heckman, 1979), but do not include the variable cross-licensing which was used to create a valid exclusion restriction in the first stage models (Cameron and Trivedi, 2009). Model 6 enters only the control variables, also presenting a few statistically significant effects: *licensor's citations* ($p < 0.05$), R&D intensity ($p < 0.05$) and Solvency ratio ($p < 0.05$). Model 7 includes the variable royalty rate, which presents a negative and highly significant coefficient ($p < 0.01$). This finding is in line with the literature on technology licensing suggesting a tradeoff between present and future revenue. Model 8 introduces the variable financial constraints in the second stage equations. Finally, model 9 includes the interaction term between financial constraints and royalty rate. As proposed in hypothesis 2, the coefficient for this interaction term is negative and significant ($p < 0.05$). This result confirms the idea that the sensitivity of the upfront fee amount to the royalty rate will be lower in absolute terms for financially constrained licensors. In order to investigate if the inclusion of this interaction term provides statistical improvement, we use a Wald test to verify the joint statistical significance for royalty rate, financial constraints and their interaction. The results suggest that adding the interaction term creates an overall statistically significant improvement in the fit of the model ($p < 0.05$).

Conclusion and Discussion

In this paper we have examined whether patent licensing contracts can be a useful source of financing for financially constrained firms. Whereas there is a growing attention to patent licenses in the literature, scant attention has been dedicated to the use of licenses as a source of financing. We believe that this is an important issue since licensing agreements could contribute to the financing of innovation more effectively than other forms of IP-backed financing. In fact, they may involve lower transaction costs than a financial transaction in which the patents are used as collateral. Moreover, licensing agreements are likely to be less affected by information asymmetries, as the licensee is presumed to know the underlying technology and its potential value better than a financial institution or an institutional investor.

These characteristics make licensing agreements a potentially viable solution to finance innovation for smaller firms. However, there is a potential drawback. Financially constrained licensors might forego a (too) high share of royalties in order to obtain more cash up front. If this is true, the beneficial aspects discussed above (lower transaction costs and information asymmetries) could be more than balanced by profit losses due to the reduction of the royalty rate.

Based on this theoretical framework, we have elaborated two testable hypotheses. First, financially constrained licensors should be more likely to require an upfront fee in the contract (hypothesis 1); second, they should be more available to renounce to royalty rates in order to get a higher upfront fee (hypothesis 2). We estimate jointly the probability and the amount of the upfront fee using a two-step Heckman model. The results fully support our hypothesis 1. This result suggests that financially constrained licensors are more prone to sign a licensing contract involving the payment of an upfront fee. Indeed, the upfront fee could be seen as a way to overcome the financial constraint. We also found statistical support for

hypothesis 2 suggesting that financially constrained licensors are more likely to renounce to more royalties than a non-constrained one to obtain more fees up front.

Overall, we think that the theoretical predictions and the results presented in this paper shed new light on the use of IP assets, and specifically patents, to overcome the financial constraints of smaller high tech firms. This calls for a deeper analysis on the role of patent licenses for innovation financing. From a theoretical point of view, we believe that two issues, namely transaction costs and information asymmetries, should be investigated further to understand better whether and, above all, under which conditions patent licenses can be effective in addressing the problems related to financial constraints. Empirically, the sample should be broadened in order to improve the statistical significance of our estimations. Moreover, fine grained measures of financial constraints, transaction costs and information asymmetries would be helpful to have more robust and complete results.

Notwithstanding these limitations, this paper draws the attention on a potential use of patent licenses, as an alternative to more complex and costly IP-backed financial transactions, which could be particularly relevant for high tech and smaller firms.

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Table 1. Descriptive Statistics and Correlations Coefficients (N = 316)

Variables		Mean	S.D.	Min	Max	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
[1]	Upfront fee (Dummy)	0.65	0.48	0.00	1									
[2]	ln(Upfront Fee)	3.23	2.52	0.00	16.12									
[3]	Cross-licensing	0.14	0.35	0.00	1.00	1.00								
[4]	Financial constraints (Ratio)	0.33	0.49	-0.26	2.87	0.02	1.00							
[5]	Royalty rate	0.08	0.08	0.00	0.40	0.09	0.09	1.00						
[6]	Milestones	0.74	0.44	0.00	1.00	0.15	0.11	0.25	1.00					
[7]	Minimum royalty	0.19	0.39	0.00	1.00	-0.09	-0.13	0.05	0.00	1.00				
[8]	Grant-back clause	0.22	0.42	0.00	1.00	-0.02	-0.01	-0.03	0.07	-0.02	1.00			
[9]	Exclusive licensee	0.76	0.43	0.00	1.00	0.10	0.19	0.28	0.35	0.04	0.05	1.00		
[10]	Exclusive rights	0.30	0.46	0.00	1.00	0.03	0.31	0.06	0.05	-0.02	0.13	0.17	1.00	
[11]	License scope	4.28	5.03	1.00	27.00	0.00	0.04	0.02	0.00	-0.01	-0.07	0.03	0.10	1.00
[12]	Licensors' citations	1.55	2.55	0.00	14.50	-0.01	-0.06	0.03	0.12	0.09	0.16	0.02	-0.05	0.10
[13]	Licensors core technology	0.37	0.30	0.00	1.00	0.07	0.14	0.12	0.12	0.07	0.00	0.19	0.06	-0.05
[14]	Early stage technology	0.35	0.48	0.00	1.00	0.10	0.02	-0.20	0.17	-0.04	0.05	-0.07	-0.10	0.13
[15]	Licensors size	10.99	2.38	7.10	16.80	-0.08	-0.66	-0.11	-0.24	0.03	-0.06	-0.17	-0.31	0.03
[16]	R&D intensity	0.39	0.37	0.01	2.28	0.01	0.86	0.07	0.13	-0.12	0.03	0.16	0.24	0.08
[17]	Solvency ratio	134.84	369.78	0.09	2213.66	-0.14	-0.33	-0.07	-0.13	0.00	-0.06	-0.02	-0.16	-0.02
[18]	Licensee's patent stock	2.89	2.37	0.00	7.27	0.07	0.24	0.01	0.14	-0.05	0.09	0.05	0.15	-0.11
[19]	Same sector	0.41	0.49	0.00	1.00	0.16	-0.16	-0.12	0.01	-0.05	0.03	-0.28	-0.11	0.13
[20]	U.S headquarter	0.86	0.34	0.00	1.00	0.00	0.06	0.01	0.06	0.15	0.11	0.05	0.04	-0.07

Variables		Mean	S.D.	Min	Max	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
[12]	Licensors' citations	1.55	2.55	0.00	14.50	1.00								
[13]	Licensors core technology	0.37	0.30	0.00	1.00	0.01	1.00							
[14]	Early stage technology	0.35	0.48	0.00	1.00	0.06	-0.14	1.00						
[15]	Licensors size	10.99	2.38	7.10	16.80	0.08	-0.27	-0.14	1.00					

[16]	R&D intensity	0.39	0.37	0.01	2.28	-0.04	0.07	0.14	-0.57	1.00				
[17]	Solvency ratio	134.84	369.78	0.09	2213.66	0.10	-0.17	-0.13	0.72	-0.29	1.00			
[18]	Licensee's patent stock	2.89	2.37	0.00	7.27	0.15	0.13	0.10	-0.38	0.19	-0.20	1.00		
[19]	Same sector	0.41	0.49	0.00	1.00	-0.21	-0.01	0.18	-0.03	-0.14	-0.16	-0.16	1.00	
[20]	U.S headquarter	0.86	0.34	0.00	1.00	-0.07	0.18	0.08	-0.21	0.01	-0.23	0.11	-0.10	1.00

Table 2: Multivariate Analysis of the Remuneration Structure of Licensing Contracts

Stage of Analysis Sample (N)	First Stage Total Number of Contracts (316)					Second Stage Number of Contracts with Upfront Payment (207)				
	With Upfront Fee Equation (Dummy)					Ln(Upfront Fee) Equations				
	1	2	3	4	5	6	7	8	9	10
Cross-licensing	-0.618*** (0.211)	-0.618*** (0.212)	-0.573*** (0.217)	-0.580*** (0.216)	-0.590*** (0.214)					
Financial constraints (Ratio) X Royalty rate				-0.043 (0.128)	-0.197** (0.092)				-0.448** (0.198)	-0.434** (0.206)
Financial constraints (Ratio)			0.645*** (0.199)	0.601** (0.260)	0.299** (0.149)			-0.574 (0.358)	-0.766** (0.305)	-0.661*** (0.247)
Royalty rate		0.010 (1.249)	1.305 (1.281)	1.268 (1.304)	0.628 (1.230)		-4.834*** (1.577)	-6.279*** (1.731)	-5.441*** (1.876)	-5.248*** (1.859)
Milestones	1.355*** (0.204)	1.355*** (0.207)	1.454*** (0.213)	1.460*** (0.213)	1.472*** (0.214)	0.022 (0.832)	0.285 (0.822)	-0.237 (0.832)	-0.112 (0.824)	0.058 (0.850)
Minimum royalty	0.622** (0.260)	0.622** (0.260)	0.697*** (0.261)	0.684*** (0.262)	0.668** (0.261)	-0.828 (0.501)	-0.748 (0.489)	-1.011** (0.469)	-1.054** (0.474)	-0.989** (0.478)
Grant-back clause	0.041 (0.250)	0.041 (0.250)	0.079 (0.252)	0.068 (0.255)	0.019 (0.252)	0.747* (0.427)	0.693 (0.438)	0.615 (0.442)	0.525 (0.415)	0.550 (0.407)
Exclusive Licensee	-0.361 (0.271)	-0.361 (0.275)	-0.491* (0.286)	-0.505* (0.282)	-0.536* (0.280)	0.051 (0.446)	0.167 (0.451)	0.337 (0.450)	0.261 (0.448)	0.201 (0.459)
Exclusive rights	0.206 (0.202)	0.206 (0.200)	0.103 (0.200)	0.108 (0.200)	0.113 (0.200)	-0.342 (0.356)	-0.377 (0.357)	-0.360 (0.377)	-0.347 (0.362)	-0.329 (0.356)
License scope	0.039* (0.021)	0.039* (0.021)	0.039* (0.021)	0.039* (0.021)	0.039* (0.021)	-0.005 (0.032)	-0.001 (0.031)	-0.011 (0.031)	-0.009 (0.031)	-0.005 (0.031)
Licensor's citations	0.007	0.007	0.005	0.006	0.005	-0.185**	-0.179**	-0.170**	-0.170**	-0.173**

	(0.039)	(0.039)	(0.041)	(0.041)	(0.041)	(0.071)	(0.070)	(0.068)	(0.067)	(0.067)
Licensors core technology	0.240	0.240	0.133	0.153	0.244	0.067	0.070	0.137	0.041	0.040
	(0.338)	(0.338)	(0.352)	(0.349)	(0.346)	(0.665)	(0.636)	(0.614)	(0.614)	(0.617)
Early stage technology	0.003	0.004	0.014	-0.003	-0.074	0.169	-0.010	-0.085	-0.217	-0.199
	(0.216)	(0.212)	(0.217)	(0.227)	(0.219)	(0.376)	(0.375)	(0.358)	(0.366)	(0.372)
Licensors size	0.024	0.024	0.123	0.120	0.121	-0.173	-0.154	-0.255*	-0.278*	-0.267*
	(0.076)	(0.076)	(0.082)	(0.083)	(0.086)	(0.139)	(0.131)	(0.150)	(0.148)	(0.144)
R&D intensity	-0.203	-0.204	-1.084**	-0.965		-1.390**	-1.291**	-0.249	0.287	
	(0.326)	(0.324)	(0.425)	(0.603)		(0.656)	(0.638)	(0.820)	(0.788)	
Solvency ratio	-0.000	-0.000	-0.001	-0.001	-0.000	0.001**	0.001**	0.002**	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Licensee's patent stock	-0.051	-0.051	-0.061	-0.060	-0.049	-0.062	-0.072	-0.059	-0.059	-0.066
	(0.042)	(0.042)	(0.045)	(0.045)	(0.043)	(0.070)	(0.068)	(0.064)	(0.063)	(0.061)
Same sector	-0.305	-0.305	-0.312	-0.314	-0.306	-0.601	-0.647	-0.552	-0.578	-0.642
	(0.214)	(0.214)	(0.217)	(0.216)	(0.215)	(0.506)	(0.488)	(0.494)	(0.486)	(0.479)
U.S headquarter	-0.830**	-0.830**	-1.067***	-1.060***	-0.958***	-0.140	-0.205	0.093	0.158	0.054
	(0.346)	(0.343)	(0.346)	(0.347)	(0.333)	(0.570)	(0.557)	(0.559)	(0.549)	(0.544)
Therapeutic Area Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Inverse Mills Ratio						0.382	0.583	-0.240	-0.106	0.170
						(1.192)	(1.175)	(1.199)	(1.191)	(1.208)
Constant	0.088	0.089	-0.104	-0.134	-0.465	14.923***	15.046***	16.086***	15.955***	15.846***
	(1.328)	(1.327)	(1.290)	(1.298)	(1.293)	207.000	207.000	207.000	207.000	207.000
Log likelihood	-143.676	-143.676	-137.335	-137.282	-138.851	-401.590	-398.033	-395.946	-393.677	-393.739

*p<0.10, **p<0.05, ***p<0.01; two-tailed tests

Robust Standard Errors in Parentheses