Abstract

This paper introduces the distinction between *thin* and *thick* contracts to the investigation of licensing-in as a mechanism for technological learning. *Thick* contracts include a clause specifying that the licensors are obligated to assist the licensees in assimilating and integrating the technology. Drawing on a sample of 133 licensees and an equal number of matched non-licensees, we present empirical evidence that *thick* contracts propel the licensees' likelihood of introducing new inventions. It is also found that thick contracts act as a substitute for licensees' absorptive capacity. Licensees that are more familiar with the licensed technology are in less need of assistance from the licensors to assimilate and integrate the knowledge. However, this substitution effect is neutralized once the hurdle of invention has been overcome, meaning that the licensees have succeeded to ignite the invention process, suggesting the exploitation of the learning curve, triggered by their mutual understanding.

Keywords

Licensing, Thin and thick contracts, absorptive capacity, technological learning

1. Introduction

Firms increasingly turn to strategic technology partnering as a means to achieve a competitive advantage. Partnering has been argued to be associated with organizational learning (Mowery et al., 1996; Steensma, 1996; Koza and Lewin, 1998; e.g. Lane and Lubatkin, 1998; Schoenmakers and Duysters, 2006), which is "*a purposive quest to retain and improve competitiveness, productivity and innovativeness in uncertain technological and market circumstances*" (Dodgson, 1993: 378). Indeed, technology partnering allows firms to harness organizational learning through re-combinations (e.g. Schumpeter, 1934; Cohen and Levinthal, 1990; Zander and Kogut, 1995). Technology licensing in particular gives the recipient of the technology (licensee) a sustainable competitive advantage (Lin, 2003) and allows the licensee to exploit the potential of combining the licensed technologies with internal resources (Lowe and Taylor, 1998; Tsai and Wang, 2007), spurs technological learning manifested in further invention (Johnson, 2002), faster invention output (Leone and Reichstein, 2012) or wider technological exploration (Laursen et al., 2010).

Firms' ability to reap the invention benefits of strategic technology partnering may depend on the structure of the signed contract (Argyres et al., 2007; Berends et al., 2011; Hagedoorn and Hesen, 2007). Technology partnering can be designed along a continuum of different contractual specifications that dictates the degree of mutual commitment (Leonard-Barton, 1995). The contractual specification used in the contract may govern critical aspects of the mutual commitment between the involved parties. Little, however, has been done so far to understand these dynamics (see Leone and Reichstein (2012) for an exception).

This paper suggests that a technology license agreement can act as a device for gaining access to other firms' capabilities (Gallini and Winter, 1985; Mowery et al., 1996; Lin, 2003) and extend it by proposing a theoretical distinction between *thick* and *thin* contracts. *Thick* contracts are characterized by contractual schemes that precipitate a relatively high information flow, wherefore the costs of reverse engineering, assimilation and integration of the knowledge into the receiving firms own knowledge bodies are relatively low. *Thin* contracts, on the other hand, contain contractual specifications provoking a relatively low level of information flow between involved parties. Licensees' endeavor to utilize the technology for learning purposes tend to be relatively more demanding and hence require more resources when the contract is thin. *Thick* contracts are argued to act as a substitute for licensees' absorptive capacity. For this reason, we suggest *thick* contracts to be less important when the firm has absorptive capacity to assimilate and integrate the licensed technology.

We draw on a sample of 133 licensees and an equal number of matched non-licensees to investigate the proposed associations. We extract relational information from the license agreements as well as the contractual specifications. We couple this data with USPTO patent data allowing us to generate ex ante and ex post technological profiles of the organizations. The paper provides empirical evidence suggesting that absorptive capacity and *thick* contracts are substitutes as instigators of organizational learning. On the one hand, when a licensee has relatively low absorptive capacity in the technology domain, the *thick* contract propels the likelihood that the licensee invents; on the other hand, when the licensee has a certain level of absorptive capacity in the domain, the *thick* contract is rendered insignificant in terms of explaining the likelihood of organizational learning. However, this substitution effect is neutralized once the hurdle of organizational learning has been overcome, suggesting the exploitation of the learning curve, triggered by their mutual commitment.

2. License contracts as repositories of inter-firm knowledge

Technology in-licensing has traditionally been associated with organizations that suffer from a technological deficiency (Lowe and Taylor, 1998) and thought to be a way for organizations to get rapid access to already proven mature external technology, avoiding much of the financial exposure and time to market that innovation activities otherwise entail (Roberts and Berry, 1985; Atuahene-Gima, 1993; Chatterji, 1996). More recent contributions suggest, however, that technology in-licensing has increasingly become a vehicle for organizations to tap into other organizations' research outcomes (e.g. Arora et al., 2001; Link and Scott, 2002; Ceccagnoli and Jian, 2013), allowing the licensee to augment its R&D capacity (Markman et al., 2005), so that it may spur technological exploration (Laursen et al., 2010) and foster invention speed (Leone and Reichstein, 2012). In the words of Tsai and Wang (2007: 152): "*by inward technology licensing, the firm may accumulate its technological knowledge and* *strengthen its technological capability from the search and use of external technology*".

2.1. Licensees' absorptive capacity

Learning implies an organization's ability to (re)act on stimuli, which can be either internal or external to the organization (Steensma, 1996). In the case of technology partnering, the stimulus corresponds to the technology/technical competence, which is acquired from the external partner triggering learning. The effectiveness of such learning depends *"on a firm's ability to identify, assimilate and utilize a partner's knowledge*" (Lane and Lubatkin, 1998:461; Cohen and Levinthal, 1989; 1990). It is a function of the recipient organization's relative experience with similar technologies (see. e. g. Cohen and Levinthal, 1990; Zahra and George, 2002; Teece, 1977; Steensma, 1996). Familiarity with the new knowledge hence conditions the ability to screen, value, and utilize external technologies and to effectively commit and combine resources into external technology sourcing, either explorative and exploitative (Rothaermel and Alexandre, 2009).

A licensee's absorptive capacity augments its learning potential and increases the likelihood that the firm will be able to effectively combine the technology with in-house knowledge assets, thereby producing new inventions (e.g. new patents). Ceccagnoli and Jiang (2013: 405) in fact suggest that, if a licensee "*has a weak absorptive capacity as a result of little investment in the monitoring of and learning from external developments […], we can expect that the buyer's cost of the integrating external technologies will be high*".

Hypothesis 1a: Licensees with a higher absorptive capacity in the licensed technology also have a higher likelihood of introducing new inventions.

However, a higher level of absorptive capacity also suggests that the firm possesses much of the knowledge embedded in the licensed technology in-house. This circumstance entails the risk that the licensee obtains a technological asset too close to the firm's own knowledge pool, wherefore the firm already may have exhausted a large share of the invention potential it represents. The technological exploration potential of licensing-in (Laursen et al., 2010) is downsized under such circumstances. Conversely, a larger technology gap between the licensor and the licensee "*leaves much room for the recipient to further develop its own firm-specific knowledge with technological learning*" (Lin, 2003:330) and therefore positively affects the scope of the invention activity. While knowledge redundancy is an important factor shaping the likelihood of knowledge creation and innovation, variety, however, is a prerequisite for fueling the inventiveness scope (Van de Ven, 1986; Nonaka, 1994). Therefore, since the extent of inventions is likely to be embedded in whether the organization invents or not, we hypothesize that:

Hypothesis 1b: Conditional on being inventive, licensees with high absorptive capacity in the licensed technology generate fewer inventions than those with lower absorptive capacity.

2.2. *Thin* or *Thick*? The impact of the contractual structure of licensing

Technological licensing is traditionally characterized by a low level of mutual commitment (Schilling and Steensma, 2002) since "*the separation between the licensor and the licensee limits the access of licensees to the scientific and technological knowledge underlying*" the licensed technology (Mulotte et al., 2013: 360). As a consequence, the recipient firm "*would likely remain dependent upon […] [the licensor] for future alteration of the technology*" (Steensma, 1996: 274). They are often referred to as arm's length contracts (e.g. Steensma, 1996; Fosfuri, 2006; Schilling and Steensma, 2002), unilateral contracts (Mowery et al., 1996:80) or loosely coupled arrangements, (Schilling and Steensma, 2002).

However, license agreements can be much more than contracts with the sole purpose of transferring a technology from one organization to another (Anand and Khanna, 2000; Bessy et al., 2002; Somaya et al., 2010). Licensing contracts are negotiated in a complex environment (Hagedoorn and Hesen, 2007), leading to sophisticated contractual structures (Anand and Khanna, 2000), and they can even be implanted in a broader agreement (Hagedoorn et al., 2008). They frequently involve a number of contractual clauses and safeguards, which affect the outcome of the relationship (see e.g. Somaya et al. (2010) on the exclusivity clause and Leone and Reichstein (2012) on the grant-back clause).

We propose that license contracts can be tailored as *thick* contracts, playing the "*…important role as repositories of inter-firm knowledge, in addition to their role as frameworks for governing exchange*" (Mayer and Argyres, 2004:395). The following quote by the director of marketing for Microsoft's Intellectual Property Licensing division[1] illuminates this point also from a practical point of view.

> *"There are different levels of collaboration between Microsoft and licensees. In the case of PlanetEye, our developers worked with theirs for several months to productize the raw technology. This high-collaboration model is similar to the integration found with our IP Ventures program, through which we are in touch with venture capitalists and economic development agencies throughout the world. But if collaboration isn't a priority, we also have a "low-touch" model of licensing, under which there's relatively little interaction between Microsoft and the licensing company or individual*" (Tenczar, 2008)

Thick licensing contracts provide the ground for disclosure and exchange of additional information and knowledge beyond what is described in the transmitted documents and blueprints (e.g. patent files). Accordingly, license agreements may contain a clause, generally known as a *Technical Assistance* clause, that obligates the licensor to assist the licensee in assimilating and integrating the technology (Macho-Stadler et al., 1996; Parr and Smith, 2005). According to Macho-Stadler (1996: 53) *"[t]he transfer of know-how can take the form of training, better modes of using the patent, specific information on the patent, etc.*". The enforcement of such a clause implies that the interaction between the two organizations would not be limited to initial implementation and minimal support (Steensma, 1996). Rather it would entail an inter-firm osmosis and a potential for a deeper level of technology acquisition and learning. With the

[1] The full text of the interview to Bob Tenczar, director of marketing for Microsoft's Intellectual Property Licensing division on "Building a Business around Licensed Technology" (June, 2008), is available at http://www.microsoft.com/en-us/news/features/2008/jul08/07-30qaplaneteye.aspx, retrieved date 12 December 2013.

inclusion of such a clause, technology in-licensing may turn into a more structured partnership for gaining *access* to other firms' capabilities (Gallini and Winter, 1985; Mowery et al., 1996; Lin, 1997). Establishing a commitment from the licensor to assist in absorbing the technology opens up the potential of learning from the licensor and creates room for both purposeful and accidental learning (Somaya et al., 2010). Hence, it can also be argued that licensees negotiating *thick* contracts are more likely to engage in technology in-licensing with the aim of learning and technology development rather than purely doing so for legal or tactical purposes. The same reasoning may apply for the licensor in the sense that she will be willing to invest some time with the licensee, if she foresees some future benefits from the relationship (Parr and Smith, 2005).

Thick contracts indicate that the licensee considers licensing an integral part of its innovation strategy. It provides access to the licensor's knowledge base and thereby spurs both the likelihood and the extent of technological learning, which manifests itself in inventive capacity.

Hypothesis 2a: Thick technology license contracts are associated with licensees with a higher likelihood of becoming inventive

Again, considering that the invention intensity is likely to be embedded in whether the organization invents or not, we also hypothesize that:

Hypothesis 2b: Conditional on being inventive, thick technology licensing contracts are associated with licensees that produce more inventions

2.3. Licensees' Absorptive Capacity in *Thick* Licensing Contracts

The flow of tacit information between licensee and licensor may be hampered due to a licensee's lack of absorptive capacity. Similarly, Agrawal (2006: 65) suggested that not all the valuable information and knowledge licensed is codified (latent knowledge) and therefore "*the only way for the licensee to access it is to work directly with the inventor*". In this circumstance the absorptive capacity may be less critical if the recipient firm has the chance to get access to complementary knowledge. In the same vein, some authors have theoretically addressed this issue, by modelling the interplay between licensees' absorptive capacity and the suppliers' knowledge transfer capability, suggesting that the importance of the latter increases when the former is lower (Ceccagnoli and Jiang, 2013).

We argue that *thick* contracts may moderate the impact of absorptive capacity. Learning from a familiar licensed technology may be influenced by the possibility to gain access to the licensor's knowledge base, through *thick* contracting. A cognitively close (familiar) technology, i.e. a higher level of absorptive capacity of the licensee firm, suggests a low level of resource heterogeneity between licensee and licensor and a higher ability to integrate the external knowledge for internal benefits and produce new inventions as a result of the technological learning. Under these conditions, licensees are in less need of relying on learning from licensors.

Hypothesis 3a: The positive association between licensees' absorptive capacity and licensees' likelihood of inventing is weakened when the license contract is thick

However, redundancy can also have a positive impact on inventing. Redundancy acts as an engine for mutual understanding and facilitates the exchange of knowledge and information (Nonaka, 1994). As also stated by Argyres et al. (2007:8) "as two parties work together, they gain valuable knowledge both about the future of their transactions, and about each other's idiosyncrasies more generally". The limited cognitive distance between partners may therefore create room for inventiveness once the hurdle of invention has passed. It catalyzes the exchange of both formalized and tacit knowledge between partners and facilitates the articulation of ideas and problems. Indeed, "...redundant information provides a vehicle for problem generation and knowledge creation which follows procedures that are different from those specified by the 'official' organizational structure" (Nonaka, 1994: 28). Without this redundancy, exchange of knowledge and information is hampered and complementarities between partners become difficult to identify. The learning effect from the licensor then becomes negligible and in turn leads to an insignificant effect on the number of inventions. Accordingly, given that the extent of invention activity is likely to be embedded in whether the organization invents or not, we put forward the following hypothesis:

Hypothesis 3b: Conditional on being inventive, the negative association between licensees' absorptive capacity and licensees' number of inventions produced is positively moderated by thick contracting

3. Data and Method

3.1. Data

We draw on an Intellectual Property Rights database on license agreements established and maintained by the Financial Valuation Group (FVG)[2]. FVG is a professional consultancy firm specialized in financial valuation and litigation support focusing on, among other things, intellectual property, patents, and specifications in contractual relations. This dataset was also employed in Laursen et al. (2010) and Leone and Reichstein (2012).

The original dataset contains 600 patent license agreements. Two circumstances, however, made it impossible to retrieve the needed data for all 600. First, some of the original license agreements were not disposable and not referenced in firm filings (e.g. S1, 8K, and 10K) at the Securities and Exchange Commission (SEC). Second, parties have agreed to keep some details confidential (i.e. patent identification number; inclusion of specific clause). We also disregarded settlement agreements, which allowed us avoid licensing contract signed only to remove IPR obstacles (exposure to infringement). This left 227 license agreements.

We integrated the license agreement data with US Patent and Trademark Office (USPTO) data drawn from the NBER (National Bureau of Economic Research) patent database. It covers all patents granted by the USPTO up to 2002 (see Hall, Jaffe and Trajtenberg, 2001, for a detailed description of the dataset). We used the USPTO patent database search engine to update the NBER dataset to May

[2] The Financial Valuation Group of Florida, Inc., The Financial Valuation Group of Ft. Lauderdale, Inc. and The Financial Valuation Group of New England, LLC (d/b/a/ The Financial Valuation Group) are forensic accounting, business valuation, and consulting services firms in Tampa and Ft. Lauderdale, Florida and Kingston, Rhode Island. (http://www.fvgfl.com/, accessed August 2014).

2008 for our sample of firms allowing us to investigate ex post patenting behavior of the organizations, involved in the most recent agreements.

The number of observations was lowered further for three reasons. First, 76 of the 227 license agreements were dropped since we could not identify the licensee in the NBER dataset. Second, 11 observations were disregarded since we were unable to find key information concerning the patent-based variables (claims and generality index). Finally, we excluded a small number of observations (7) because it proved impossible to find comparable non-licensees for companies such as Microsoft, Abbott Laboratories, Siemens, IBM, Procter and Gamble, Ericsson, and Hitachi, due to the immense size of their patent portfolios. We found the remaining 133 to be mirrored in those we removed on a number of dimensions, therefore considering them representative. Given the resulting sampling, our results may not be generalized to very large firms with extremely large patent portfolios.

3.1.1. Matched Sample

In line with Leone and Reichstein (2012), we relied on a combination of exact and propensity score matching to generate a sample of non-licensees for comparison. We ensured the licensees and non-licensees are comparable in the month at which the licensee signed the license agreement keeping chronology fixed between treatment and control samples. Furthermore, we secured that licensee and non-licensee invent primarily in the same technological class. This ensures that the matched pairs also have similar barriers to invention.

The propensity score matching (Rosenbaum and Rubin, 1983) allows the use of multiple continuous regressors to identify a matched control sample. We used a logistic specification. We also matched with replacements allowing for a non-licensee to be identified as the designated match with multiple licensees.

The performance of propensity score matching relies heavily on the data and measures used as inputs (Heckman et al., 1997). Matching variables are selected so that they convey information about firms' invention and patenting strategy since technology licensing often is an integral part of the firm's invention strategy. We use five variables in the propensity score matching procedure which are all based on NBER patent data; *patent stock*, *average number of citations*, *average time between patents*, *technological diversity*, and whether the firm is a *technological collaborator*.

We searched the Thomson Research Database for indications of technology licensing activities over a five year period (2 years before and after time of comparison) among the most prominent matching firms. S1, 10K, and 8K filings often reveal whether a firm has engaged in licensing activities. When no evidence of licensing activity was found through these channels, we searched on Google using "License agreement" and company names as search criteria. Google searches SEC filings for licensing activities, thereby also checking filings by licensors. We categorized firms as non-licensees if none of these sources revealed any evidence of the contrary. The final sample contains 266 observations (133 licensee and 133 comparable non-licensees).

3.1.2. Dependent Variables

Invention Performance: Number of patents applied for within five years after the point in time at which the licensee signed the license agreement is used as the dependent variable. Since the updated NBER patent database contains only successful patent applications, our definition of invention is granted applications.

3.1.3. Explanatory Variables

Licensee: The matching procedure provides a dummy variable for being a licensee (treatment vs. control sample). We interpret this dummy as a measure of obtaining blue-prints and property rights to the licensed technology representing the potential source of learning from licensed technology.

Absorptive Capacity: Licensees' *absorptive capacity* with regard to the licensed technology was measured using Ziedonis's (2007) focus index. It measures the share of patents granted in the six years prior to licensing that are in the same IPC as the patent(s) included in the license agreement. Having a higher technological experience and more focus on a specific technology allows the firm to more easily assimilate it and integrate it into its own technology.

Thick License Contract: We distinguish between *thin* and *thick* contracts by the usage of a contractual specification in the agreements, namely a *technical assistance clause*[3], in which the licensor agrees to assist the licensee in assimilating and integrating the technology. Licensors may assist licensees even when the clause is not present. However, the inclusion of the clause not only ensures that the

[3] The sample of contracts used in this paper contains several ways of invoking this clause. A typical example reads: "Subject to RS's reasonable availability and payment to RS of costs associated herein, RS shall provide certain technical assistance to RJ" (Newstate Holdings Inc, SB-2, on 12/20/96 Document 13 of 23, EX-10.5, Technology License Agreement, available at http://www.secinfo.com/dRqWm.9t42.2.htm, retrieved on January 2012).

licensor will actively collaborate with the licensee. It also indicates that the licensee recognizes a value in the extra technical information the licensor would provide beyond the patented technology.

3.1.4. Matching Variables

Five variables were used in the propensity score matching procedure. First, firms' inventiveness is measured as the logarithm of patents granted to the firm (*Patent Stock*) prior to the licensing event. Organizations with a larger pool of potential complementary technological assets are more likely to license-in since they have a greater chance of successfully combining the acquired technology with in-house technology.

Second, *Average Number of Citations* received to the patent portfolio indicates the firms' ability to produce major inventions. Numerous citations may also be an indicator of extensive network relations, which, in turn, may increase the potential for licensing activity.

Third, patenting frequency is quantified as the *Average Time Between Patents* granted prior to the license agreement. It indicates the intensity of the firm's invention strategy and therefore may be suggestive of the tendency to make use of external sources like licensing.

Fourth, *Technological Diversity* is measured as the number of different IPC codes a firm has patented in. Diversity may suggest that a firm has rather extensive invention capabilities, which, in turn, may increase the number of potential licensing-in technologies.

Finally, being a *Technological Collaborator* is indicative of firms pursuing an open innovation strategy drawing on external sources of information and knowledge. Therefore, we expect firms that are co-assignees also to be more likely to engage in technology licensing.

3.1.5. Control Variables

We account for firms' search strategies, using the Katila and Ahuja (2002) search scope and search depth measures. *Search Depth* is defined as the average number of times a firm cites patents repeatedly in its patent applications. *Search Scope* is defined as the proportion of citations in a firm's patent applications cited in the previous five years. We use the number of years between the first applied patent and the time of the license agreement as a measure of *Technological Experience*. The firm's ability to produce inventions useful as inputs to multiple technological classes may influence the firm's decision and ability to patent. We use the maximum *Patent Stock Generality* index as a measure of applicability of the existing portfolio of technology (see Hall and Trajtenberg, 2004 for details). Following Lanjouw and Schankerman (1999), firms' technological complexity is measured by the *Average Number of Claims* on patent grants prior to the license agreement. Firms' familiarity with complex technologies promotes their ability to absorb new knowledge and integrate it into their existing knowledge bases (Lin, 2003). A grant-back clause may shift the incentive for investing resources and time into invention activities away from the licensee and towards the licensor (Leone and Reichstein, 2012). Accordingly we dummy control for the use of the *Grant-back clause* in explaining the licensee's inventiveness. Finally, we use a categorical distinction to control for the size of the firm. The categories are: *Small* firms defined as less than 100 employees; *Medium* sized firms defined as 100-1,000 employees; and *Large* firms defined as firms with over 1,000 employees. Japanese and European firms may exhibit lower propensities to patent at the USPTO compared to North American firms since their first choice may be their local patent office. A Geographical location dummy is used for whether the observation is a *North American Firm* or not. The NBER technological classifications are used as a control for differences in patenting activities across technological groups: *Computers and Communications, Drugs and Medical, Electrical and Electronics, Mechanical, Others*, and *Chemicals*.

3.2. Method

Our hypotheses involve two sets of dependent variables: 1) whether an organization produces any inventions or not (H1a, H2a, and H3a), and 2) the extent of inventions the organization produces (H1b, H2b, and H3b). We follow Pohlmeier and Ulrich (1995) and apply a hurdle/two-part model to investigate a two-stage process since the extent of inventions is likely to be imbedded in whether the organization invents or not. The first stage relates to the ability of the organization to become an inventor (*likelihood to file a patent application*). The second stage involves how extensively the organization is able to invent (*number of granted patent applications*).

The hurdle model involves two density estimations. The first estimation explains the observations of a positive number of inventions determined by a density, f1 (.), so that Pr[y>0] =f1(y). The second is a truncated density function estimation explaining the number of inventions. This may be written as f2(y|y>0)=f2(y)/(1-f2(0)). The hurdle model multiplies f2(y|y>0) with (1-f1(0)) to ensure that the probabilities of the outcomes sum to unity. We follow McDowell (2003) and use a complementary log-logistic specification for the first part and a truncated Poisson specification to model the positive outcomes in the second part.

3.3. Results

Table 1 contains the mean and standard deviations of all the variables used in the analysis and the associated Pearson correlation. 59% of the observations (157 of 266) have patent activity within 5 years of the licensing event of the licensee or the matched licensee. We also observe that the average number of patents among the firms is just above 10. The distribution of the number of patents is right skewed. Approximately 10% of the investigated contracts and licensees are subject to a technical assistance clause. Table 1 also reveals relatively low Pearson correlation coefficients between the variables used in the model, indicating little reason for concern on multicollinearity.

INSERT TABLE 1 ABOUT HERE

Table 2 reports the results of two hurdle models. Model 2 includes the interaction between "Absorptive Capacity" and *"Thick License Contract",* allowing us to investigate hypotheses 3a and 3b.

Hurdle Models 1 and 2 exhibit a significant positive estimate associated with absorptive capacity in the complementary log-logistic regression supporting Hypothesis 1a: *Licensees with a higher absorptive capacity in the licensed* *technology are associated with higher likelihoods of introducing new inventions.* We find only limited support for hypothesis 1b: *Conditional on being inventive, licensees with high absorptive capacity in the licensed technology are associated with fewer inventions than those with lower absorptive capacity*. While the estimate is insignificant in Hurdle Model 1, Hurdle Model 2 exhibits a weakly significant negative sign for absorptive capacity in the truncated Poisson regression analysis.

Thick partnership is also significantly positive in the complementary log-logistic specification in Model 2 and a little less significant in the corresponding regression in model 1. This provides support for Hypothesis 2a: *Thick technology license contracts are associated with licensees with a higher likelihood of becoming inventive.* We find no support for Hypothesis 2b: *Conditional on being inventive, thick technology licensing contracts are associated with licensees that produce more inventions.* There is in fact a slight tendency for a negative sign in Hurdle Model 2 indicating the opposite. This estimate, however, is weak at best.

INSERT TABLE 2 ABOUT HERE

The estimate of the interaction term is negative in the complementary log-logistic regression and positive in the truncated Poisson. These are significant at a 5% level and 1% level respectively. The regression thereby supports Hypothesis 3a: *the positive association between licensees' absorptive capacity and licensees' likelihood of inventing is weakened when the license* contract *is thick* and Hypothesis 3b: *Conditional on being inventive, the negative association between licensees' absorptive capacity and licensees' number of inventions produced is positively moderated by thick contracting.* The complementary log-logistic regression also suggests little absorptive capacity is needed before the effect of the *thick* partnership becomes significant in predicting the likelihood of overcoming the invention hurdle. Not until multiplying the parameter of the interaction term with 0.05 can we consider the combined effect of the two estimates to be significantly positive. The results are very different when considering the truncated Poisson. The parameter estimate associated with the interaction effect is much higher than the *thick* partnership estimate in absolute terms. Even medium absorptive capacity (multiplying the parameter of the interaction effect with 0.6) will create learning benefits from the licensor, which in turn allow the licensee to patent more extensively.

Figure 1 exhibits the marginal effects of the interaction term. The figure exhibits an increasingly positive impact of absorptive capacity when the contractual specification is *thin,* while there is a negative marginal impact of absorptive capacity in the presence of *thick* contracting. This suggests a substitution effect between *thick* contracting and absorptive capacity. The graphs, however, also suggest the conclusions to be made with caution. The figure on the right exhibits the significance of the difference between the curves in the figure on the left indicating the difference only to be found in the lower values of absorptive capacity.

INSERT FIGURE 1 ABOUT HERE

We also find positive coefficients associated with the licensee variable in both the complementary log-logistic regressions and the truncated Poisson regressions, suggesting that licensees are both more likely to invent and invent more extensively than comparable non-licensees. We also find that firms with a large ex ante patent stock, high ex ante average number of cites, and characterized by higher search scope exhibit higher propensities to invent and invent more extensively. Results also indicate that firms with a high average time between patents, and that exhibit a high technological diversity, and a high number of claims display the lowest propensities to patent. Technological experience and generality seem to be negatively associated with the extent of patenting.

3.4. Supplementary Analysis

To support the underlying reasoning of the paper and to investigate the degree to which knowledge in fact is transferred from licensor to licensee, we investigated whether licensees cite the patents of the licensor ex post the license agreement given the contractual structure and not considering citing the licensed patent. The citation pattern should be stronger in cases with *thick* contracting since it is hypothesized to open up a wider channel of information between the licensee and the licensor. About 16 percent of the licensees cited the licensor prior to the license agreement. Among the licensees that had secured a *thick* contract, only 11 percent cited the licensor prior to the license agreement. The corresponding percent among those without the clause is 18. This may indicate that licensees who did not work intensively with the licensors' technology prior to licensing tend to be more likely to make use of *thick* contracts. Considering citation of the licensor ex post the license agreement, we found that the percentage of licensees that cited licensor *ex post* compared to *ex ante* was unaltered for those that used *thick* contracting, whereas the citation tendency dropped among those that chose to adopt *thin* contracting. These findings provide some supplementary evidence in favor of licensing contracts acting as a mechanism through which the licensee not only may get access to the knowledge embedded in the licensed technology, but also may be a key that unlocks some of the additional knowledge which is embedded in the licensor.

To further support these findings, which assume that the thick contracts are more than just a contractual fab, we looked for some anecdotal evidence pointing in this direction. Specifically, we looked for evidence that especially large organizations would find it worth their while to engage, since this would make a more profound and strong indication that licensors in fact are willing to do so. We found that AT&T has a technology licensing program which involves furnishing partners with additional assistance aiming to enhance their business.

> *"AT&T Intellectual Property manages a vigorous Patent Licensing program. Please contact us to learn which patents are available for licensing and how licensing certain technologies could enhance your business."*[4]

The AT&T statement suggests their licensing program to be proactive, trying to find suitable partners for their technologies. In addition, they indicate a willingness to help potential licensing partners to understand the technologies and how they may become assets for them. The following statement by IBM indicates a similar program, which also offers additional services to the potential partner.

[4] http://www.att.com/gen/sites/ipsales?pid=17702, accessed June, 2015

> *"Working with IBM's IP means much more than licensing patents. Clients can work directly with members of IBM's team of 250,000 scientists, researchers, engineers, developers and technologists who built one of the world's largest IP portfolios. This broad collaboration creates a diversity of viewpoints, backgrounds and expertise that enables profound new solutions."*[5]

IBM hence has an out-licensing program in which they offer more than just technology. They offer various resources that may assist the potential licensee in understand the technology in various aspects including technicalities, development, and business application.

These examples not only suggest there are conditions which motivate the licensor in taking steps towards assisting the licensee with regard to the technologies that may be licensed. But it also indicates that there are different degrees to which licensors will do this and that there are differences in the resources they will reserve for assisting the licensee. We believe these examples provide some food for thought with regard to the thin versus thick contracts and their role in licensing deals.

4. Conclusions and Implications

This paper provides evidence that technology licensing is more than arm's-length contract arrangements. Licensing-in is associated with increased invention activities and the strength of this association is governed by contractual specifications and firms' absorptive capacity in the specific technological field. We

[5] http://www.ibm.com/ibm/licensing/, accessed June, 2015

introduced the concept of *thick* versus *thin* licensing contracts and empirically investigated the use of licensing-in as a mechanism for technological invention, putting particular emphasis on the interplay between absorptive capacity and *thick* contracts. Absorptive capacity is found to be associated with greater likelihoods of becoming inventive when licensing-in a technology. It does, however, not exhibit any strong correlation with the extent of invention activities. This may suggest that high absorptive capacity in the technological space in which the firm is licensing often represents only few invention opportunities rather than a more explorative behavior which may offer a more extensive landscape of opportunities, thereby giving a muddier pattern for the extent of invention ex post licensing-in.

Thick contracts also represent a rewarding behavior of contracting, lowering the hurdle of introducing a new invention. The investigation, however, does not indicate any effect of *thick* contracts on the extent of invention activity. The *thick* contracts, however, act as a substitution for absorptive capacity in the likelihood of passing the hurdle of inventing. Both *thick* contracts and absorptive capacity represent two similar ways of driving the invention process in terms of generating at least one invention. *Thick* contracts may play a similar role as absorptive capacity in which case *thick* contracts are an extended arm for the licensees' technological capabilities. This is well in line with existing research pointing out the need for redundancy of knowledge and information to achieve fruitful knowledge creation (Van de Ven, 1986; Nonaka, 1994), and that the identification of entrepreneurial opportunities depends on prior knowledge (Shane, 2000). Once a fruitful invention path has been identified, absorptive capacity and *thick* contracts may indeed be complements producing extensive benefits in terms of scope of invention activities.

This study clearly provides evidence suggesting new directions of future studies on technology partnerships. More specifically, this paper underlines the necessity of understanding the underlying contractual agreements when investigating the effects and advantages of technological partnerships. Partnerships are not homogeneous in their forms or nature but entail different forms of relations, which have major implications for their outcomes. In addition, we believe this stream of literature may have major potentials for disentangling the various mechanisms and incentives present in technological partnerships. Indeed, licensing agreements, due to the availability of the contractual specifications and their contractual flexibilities and possibilities, constitute a powerful instrument for investigating such partnerships, which may hold the key for further understanding of the premises of optimal contractual forms in agreements pertaining to technological collaboration.

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Table 1: Descriptive Statistics and Pearson Correlation Coefficients (N=266)

		Mean	S.D.	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
[1]	Patent Activity	0.59	0.49												
[2]	No. of Patents	10.65	52.77	0.17											
[3]	Thick Partnership × Absorptive Capacity	0.02	0.12	0.05	0.07										
[4]	Thick Partnership	0.10	0.30	0.23	0.21	0.41									
[5]	Absorptive Capacity	0.10	0.25	0.17	0.03	0.42	0.08								
[6]	Licensee	0.50	0.50	0.30	0.17	0.14	0.34	0.39							
[7]	Patent Stock	1.20	1.12	0.17	0.54	-0.03	0.21	-0.05	0.07						
[8]	Average Number of Cites	9.69	14.96	0.09	0.05	0.30	0.26	0.07	0.01	0.11					
[9]	Average Time Between Patents	21.58	34.04	-0.15	-0.09	-0.05	-0.02	-0.12	-0.01	-0.10	0.08				
[10]	Technological Diversity	3.05	15.00	0.09	0.74	-0.02	0.21	-0.04	0.08	0.65	-0.02	-0.07			
[11]	Technological Collaborator	0.06	0.25	0.06	0.37	0.02	0.17	0.02	0.11	0.33	-0.01	0.03	0.33		
[12]	Computers and Communications	0.10	0.30	-0.06	-0.03	0.17	0.18	0.07	0.00	-0.11	0.28	-0.03	-0.05	-0.09	
[13]	Drugs and Medical	0.36	0.48	0.08	-0.03	-0.02	-0.10	0.10	0.00	-0.09	0.06	-0.13	-0.09	0.06	-0.25
[14]	Electrical and Electronics	0.09	0.29	0.02	0.11	-0.04	-0.06	-0.09	0.00	0.16	-0.02	0.01	0.10	-0.03	-0.10
[15]	Mechanical	0.05	0.21	0.07	-0.01	-0.02	0.05	-0.07	0.00	0.01	-0.05	0.27	-0.02	0.02	-0.07
[16]	Others	0.15	0.36	0.01	-0.03	-0.06	-0.04	-0.04	0.00	0.10	-0.12	0.04	0.01	-0.02	-0.14
[17]	Search Depth	0.42	1.46	0.19	0.14	-0.02	-0.01	0.21	0.18	0.20	0.04	-0.06	0.13	0.11	-0.07
[18]	Search Scope	0.32	0.42	0.24	0.14	0.03	0.10	0.07	0.02	0.15	-0.03	-0.21	0.06	0.05	-0.07
[19]	Average Number of Claims	0.80	2.43	-0.07	-0.04	0.24	0.03	0.10	-0.11	-0.09	0.34	-0.12	-0.04	-0.07	0.15
[20]	Technological Specialization	0.54	0.39	0.07	-0.11	0.01	-0.06	0.03	-0.29	-0.34	0.11	-0.03	-0.14	-0.09	0.10
[21]	Technological Experience	59.06	75.71	0.09	0.21	-0.07	0.20	-0.12	0.17	0.70	0.06	0.42	0.39	0.25	-0.15
[22]	Patent Stock Generality	0.55	0.39	-0.04	0.12	0.01	0.13	-0.06	-0.11	0.57	0.31	0.02	0.18	0.12	0.09
[23]	Grant-Back Clause	0.08	0.27	0.10	0.32	0.20	0.46	0.00	0.29	0.29	0.13	-0.09	0.30	0.15	0.14
[24]	Medium	0.28	0.45	0.06	-0.01	0.00	0.07	0.04	0.07	0.10	0.08	0.01	-0.02	0.04	0.05
[25]	Large	0.16	0.37	0.15	0.24	-0.02	0.13	-0.14	-0.04	0.26	-0.04	0.09	0.23	0.10	-0.14
[26]	North American Firm	0.86	0.35	0.07	0.06	0.06	0.07	0.16	0.24	0.01	0.12	0.02	-0.01	-0.24	0.10

		[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]	[25]
[14]	Electrical and Electronics	-0.24												
[15]	Mechanical	-0.16	-0.07											
[16]	Others	-0.32	-0.13	-0.09										
[17]	Search Depth	0.18	-0.04	-0.02	-0.04									
[18]	Search Scope	0.10	-0.05	0.08	0.10	0.24								
[19]	Average Number of Claims	0.02	-0.07	-0.03	-0.01	-0.04	0.17							
[20]	Technological Specialization	0.15	-0.10	-0.08	-0.04	0.08	0.03	0.21						
[21]	Technological Experience	-0.18	0.22	0.08	0.15	0.04	0.02	-0.19	-0.34					
[22]	Patent Stock Generality	-0.08	0.05	-0.01	-0.03	0.13	0.02	0.07	-0.20	0.39				
[23]	Grant-Back Clause	-0.16	0.10	0.00	0.03	-0.01	0.01	0.05	-0.14	0.23	0.18			
[24]	Medium	-0.01	-0.17	0.07	0.09	0.10	0.12	0.04	-0.06	0.07	0.06	0.10		
[25]	Large	-0.11	0.12	0.20	0.08	0.00	0.15	0.00	-0.09	0.27	0.05	0.10	-0.27	
[26]	North American Firm	-0.03	0.09	0.04	-0.16	0.07	-0.04	0.05	-0.10	0.00	0.03	0.00	-0.01	-0.09

Correlation coefficients above 0.11 are significant at a 5% level

Table 2: Thick Partnership, Absorptive Capacity and Inventiveness. Results of Hurdle Models

	Hurdle Model 1		Hurdle Model 2	
	Compl. Log-Log Invent vs Not invent	Truncated Poisson No. of inventions	Compl. Log-Log Innovate vs Not invent	Truncated Poisson No. of inventions
Explanatory Variables				
Thick Partnership × Absorptive Capacity			-1.242**	2.387***
			[0.700]	[0.724]
Absorptive Capacity	0.570*	-0.086	0.781**	-0.469*
	[0.406]	[0.311]	[0.440]	[0.318]
Thick Partnership	0.541*	-0.108	0.740**	-0.707*
	[0.380]	[0.528]	[0.415]	[0.516]
Licensee	1.201***	1.028***	1.152***	1.112***
	[0.290]	[0.287]	[0.292]	[0.283]
Matching Variables				
Patent Stock	0.458**	0.587***	0.452**	0.578***
	[0.255]	[0.156]	[0.257]	[0.158]
Average Number of Cites	0.020***	0.014**	0.021***	0.010
	[0.008]	[0.008]	[0.007]	[0.009]
Average Time Between Patents	-0.011**	-0.004	-0.011**	-0.004
	[0.005]	[0.008]	[0.005]	[0.007]
Technological Diversity	-0.030***	0.001	-0.031***	0.002
	[0.009]	[0.003]	[0.009]	[0.003]
Technological Collaborator	0.166	0.361	0.159	0.235
	[0.503]	[0.311]	[0.502]	[0.301]
Computers and Communications	-0.157	0.051	-0.151	0.165
	[0.358]	[0.520]	[0.352]	[0.488]
Drugs and Medical	0.128	0.239	0.118	0.145
	[0.267]	[0.262]	[0.266]	[0.232]
Electrical and Electronics	0.090	0.166	0.090	0.090
	[0.443]	[0.304]	[0.444]	[0.307]
Mechanical	0.444	0.005	0.414	-0.028
	[0.511]	[0.511]	[0.513]	[0.534]
Others	0.091	0.009	0.086	0.002
	[0.338]	[0.380]	[0.340]	[0.328]
Control Variables				
Search Depth	0.690***	-0.086*	0.704***	-0.069
	[0.262]	[0.065]	[0.271]	[0.069]
Search Scope	0.495**	0.924***	0.477**	0.846***
	[0.260]	[0.220]	[0.260]	[0.204]
Average Number of Claims	-0.150***	-0.065	-0.133***	-0.124*
	[0.054]	[0.075]	[0.050]	[0.086]
Technological Specialization	1.555***	-0.448	1.530***	-0.397
	[0.328]	[0.384]	[0.328]	[0.378]
Technological Experience	0.002	-0.006**	0.002	-0.005**
	[0.003]	[0.003]	[0.003]	[0.002]
Patent Stock Generality	-0.526*	-0.588**	-0.553*	-0.497**
	[0.362]	[0.311]	[0.367]	[0.298]
Grant-Back Clause	-0.098	0.438	-0.022	0.494*
	[0.376]	[0.350]	[0.374]	[0.376]
Medium	0.172	0.583**	0.155	0.695***
	[0.245]	[0.316]	[0.249]	[0.294]
Large	0.865***	0.781***	0.873***	0.813***
	[0.301]	[0.318]	[0.302]	[0.292]
North American Firm	0.191	0.720	0.183	0.754
	[0.332]	[0.568]	[0.332]	[0.603]
Constant	-2.420***	-0.093	-2.384***	-0.091
	[0.536]	[0.624]	[0.535]	[0.620]
Number of Observations	266	157	266	157
Log-Likelihood	-127.929	-935.754	-127.479	-883.064
χ^2	77.824***	8025.932***	79.473***	8131.311***
Pseudo R^2		0.811		0.822

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ at a one sided test, Standard errors in parentheses

Table A: Performance of the Matching Procedure. Results of Probit Model against Treatment

	Matching Model Licensee vs Non-licensee
Patent Stock	0.019
	[0.099]
Average Number of Cites	0.001
	[0.006]
Average Time Between Patents	-0.000
	[0.002]
Technological Diversity	0.006
	[0.007]
Technological Collaborator	0.485*
	[0.355]
Computers and Communications	0.035
	[0.306]
Drugs and Medical	-0.004
	[0.202]
Electrical and Electronics	-0.020
	[0.303]
Mechanical	0.014
	[0.405]
Others	0.007
	[0.253]
Constant	-0.068
	[0.189]
Number of Subjects	266
Log-Likelihood	-182.323
χ^2	7.174
Pseudo R^2	0.011

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ at a one sided test, Standard errors in parentheses

Figures

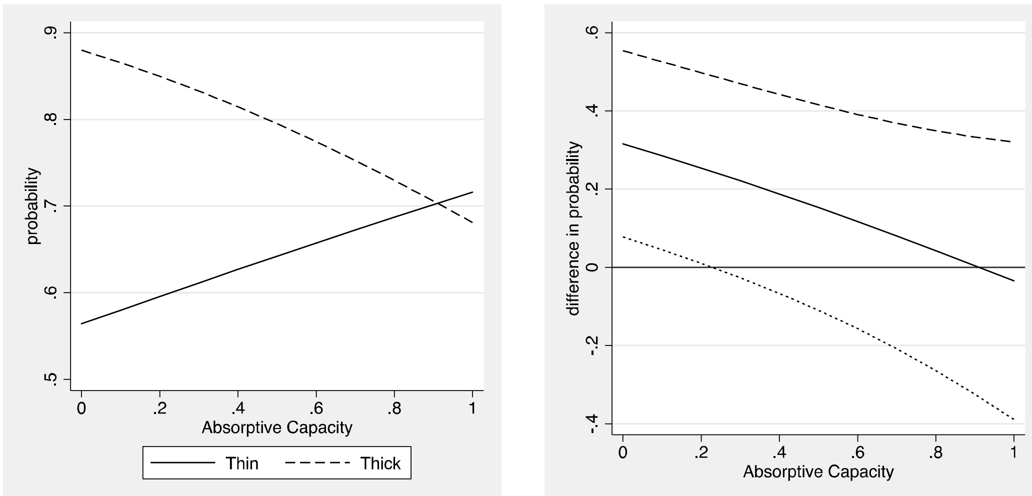

Figure 1: Margins plot of explanatory variables (left) and difference in effects (right)