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Cooperative Markets for Ideas: When does Technology Licensing Combine with R&D Partnerships?

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Abstract

The study departs from the traditional view of licensing as a spot market transaction and investigates license integration with R&D partnerships, introducing the concept of licensing combination. Drawing on licensing and R&D partnership literature and adopting the ?transactional value? approach, we propose two types of antecedents ? knowledge and dyad features ? to investigate licensing combination. Using a dataset combining 441 original license agreements with firms? patenting and market activity in the global biopharmaceutical industry, we find a substantial heterogeneity in the ways licensors and licensees jointly exploit markets for knowledge. The research highlights the specific role played by R&D collaboration and minority equity in inter-organizational exchange through licensing. Results show that licensing combination with R&D collaboration is likely when the licensed innovation is embryonic, the licensee is unfamiliar with the licensor?s technology and partners have different technological backgrounds. Instead, licensing of highly specific knowledge is likely to be supported by minority equity participation on the part of the licensee. Finally, licensing is combined with both forms of partnership in case of competence distance between partners. In the light of the empirical results, four types of licensing combination are proposed for future research.

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Abstract

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1. INTRODUCTION

Licensing is central to firms' technology strategy. Empirical evidence highlights its increasing importance among inter-firm R&D partnerships (Arora et al., 2001a; Hagedoorn, 2002). From the licensor's point of view, it represents a flexible mechanism to find markets for unexploited technologies, to set an industry standard and to access complementary asset for technology commercialization (Arora, 2003; Fosfuri, 2006; Lichtenthaler & Ernst, 2009; Teece, 1986). From the licensee's perspective, it is a valuable tool to access external proprietary knowledge, to compress the time to market by speeding up the invention process, to widen knowledge search and boost firm's absorptive capacity (Arora & Gambardella, 2010; Laursen et al., 2010). Most academic studies pertaining to both the licensing literature and R&D partnership literature have examined licensing as an arm's length market transaction where technology transfer is limited to proprietary knowledge. Such a focus is understandable since, compared to other R&D partnerships such as equity joint ventures, licensing is by far more similar to a market transaction (Fosfuri, 2006). However, a recent study by Hagedoorn, Lorenz-Orlean and van Kranenburg (2008) suggests that licensing actually entails knowledge transfer and partners' cooperation to a far greater extent than is generally recognized. Licensing is frequently embedded in broader inter-firm collaborations including activities such as co-development, co-marketing, and supply agreements. For instance, a fundamental breakthrough in the global pharmaceutical industry – Humira (i.e. a drug to reduce the symptoms of rheumatoid arthritis) – was the result of a license-R&D collaboration between Cambridge Antibody Technology and BASF. The former out-licensed the molecule to BASF and at the same time the parties formed an R&D collaboration in order for BASF to successfully commercialize the licensed drug. Thus, contrary to common perceptions, there is substantial heterogeneity in the way firms access markets for knowledge through licensing. Despite its importance, the phenomenon has been overlooked in the literature on markets for technology. In this study, we depart from the traditional view of licensing as an arm's length market transaction and attempt to fill the gap in the literature by examining when technology licensing combines with other R&D partnerships and which factors determine firms' combination choice.

Understanding the combination of licensing with other R&D forms of inter-firm collaboration has rich theoretical and empirical implications from the perspectives of markets for technology and R&D partnerships. The empirical research on licensing has studied the structure of license contracts and the use of different contractual clauses to support technology exchange and mitigate transactional hazards (Arora, 1996; Cebrian, 2009; Palomeras, 2007; Somaya et al., 2010). This literature implicitly assumes the dichotomous market-hierarchy classification of governance modes provided by transaction cost theory. The paper advances the current understanding of licensing practices, proposing a new conceptualization of the phenomenon that goes well beyond the standard market exchange classification. The main argument of the study is that, under specific conditions, licensing entails much more than the transfer of "tightly packaged" and codified knowledge and that technology transfer needs to be supported in order for firms to maximize the value from partnering. Indeed, studying the determinants of licensing combination with R&D partnerships provides insights into the different ways firms leverage technology licensing to access and benefit from markets for knowledge. This issue is of fundamental concern to technology strategy theorists trying to explain the mechanisms allowing firms to benefit from external R&D linkages.

Our analysis is further enriched by the consideration of the interests of both partners involved in the technology exchange. Unlike past studies that analyzed technology licensing from the perspective of a focal firm (Fosfuri, 2006; Laursen et al., 2010; Lichtenthaler, 2007a; Teece, 1986), we conceive of the exchange underlying the combined license as a cooperative tie between interdependent partners. Such a view highlights the importance of taking into account both parties' perspectives in explaining the choice of optimal license combination.

The study also provides insights into the broader literature on R&D partnerships. In the past, much attention has been paid to the choice between equity forms and contractual arrangements to effectively transfer knowledge, considering these forms as substitute governance mechanisms along a market-hierarchy continuum (Colombo, 2003; Gulati, 1995a; Oxley, 1989). Although the R&D partnership literature has developed an increasing interest in how these different types of governance are interrelated, most empirical evidence has been gathered at the company level of analysis, examining the reasons why firms should pursue different R&D partnerships to benefit from external knowledge (Arora & Gambardella, 1990; Hagedoorn, 1993). The present study contributes to the literature by investigating the determinants of licensing combination with either equity forms and/or contractual R&D partnerships, focusing on the transaction level of analysis. The shift to a transaction level of analysis highlights that the combination derives from a tension between firms' need for flexible access to specialized external knowledge as well as other resources through market, and firms' need to learn and integrate new knowledge and skills into existing in-house competences.

In the next sections, drawing on the knowledge-based view we propose a theoretical model linking firms' licensing combination choice to the attributes of the licensed technology and the features of the tie. The model has the following main characteristics. First, we adhere to the "joint value maximization perspective" proposed by Zajac and Olsen (1993), conceiving licensing as a voluntarily agreement between two interdependent firms. Both parties use the inter-organizational strategy to establish an ongoing relationship to create value that could otherwise not be created by either firm independently. Second, following past research on inter-firm partnerships (Arora & Gambardella, 1990), we limit the domain of our model to R&D partnerships, more specifically to R&D collaboration agreements and minority equity links. In turn, we examine when licensing is likely to be coupled with R&D collaboration, with minority equity links or with both.

Our empirical analysis draws on a sample of 441 license agreements in the global biopharmaceutical industry over the period 1985-2004. To test the research hypotheses we develop a research design relying on multiple sources of information: licensing information is combined with information about the parties to the transaction and their patenting and market activities.

2. THEORETICAL BACKGROUND

2.1 Licensing and R&D partnerships

Although licensing is the least integrated and hierarchical form among inter-firm partnerships, cooperation between partners is central for knowledge transfer to occur. The licensing literature outlines the importance of designing incentive-compatible contracts as a means to align partners' incentive to cooperate and overcome threats to technology transfer (Aghion & Tirole, 1994; Choi, 2001; Gallini & Wright, 1990). Recent studies have advanced our understanding of the licensing phenomenon, focusing on license contract structuring and the function of specific contractual clauses in easing technology exchange and mitigating issues related to partners' opportunism (Anand & Khanna, 2000; Arora, 1996; Bessy & Brousseau, 1998a). Much attention has been paid to transaction costs and transactional hazards such as contract incompleteness, knowledge leakage and hold-up issues. For instance, Somaya, Kim and Vonortas (2010) examine why exclusivity provisions are used in licensing contracts and when licensing scope restrictions are enforced. The results highlight the use of exclusivity clause as contractual hostage to safeguard licensee investments in complementary assets and to enable contracting over embryonic technologies. Cebrian (2008) analyzes licensing payment structure and how royalties, fixed payments or a combination of the two are a means to mitigate contractual hazards between parties.

Relatively few research studies on licensing have analyzed the issues linked to knowledge transfer and the mechanisms partners use to support technology exchange. Hagedoorn, Lorenz-Orlean and Van Kranenburg (2008) provide a preliminary investigation of firms' preferences between standard and partnership-embedded licensing. However, little is known about the type of licensing combination as a choice and its contingent factors relative to either the exchanged technology or the partners involved. Yet, understanding the impact of knowledge features and firms' competences on the choice of license combination would deepen our knowledge of firms' licensing practices. Further, the analysis of the governance mechanisms combined with licensing would complement the above studies, highlighting the dynamic perspective of licensing and its cooperative stance.

The study also attempts to fill a gap in the broader stream of research on R&D partnerships. Previous research has traditionally examined forms of inter-firm collaborations along a market-hierarchy continuum, assuming a substitution effect between the different forms when moving up along the hierarchy. For instance, Oxley (1997) examines firms' preferences for unilateral, bilateral or equity-based alliances as a function of the contractual hazards parties face when entering into the agreement. Similarly, Colombo (2003) analyzes firms' preferences between contractual agreements versus equity-based ones. Very few studies have examined how different governance modes are related to one another, overlooking firms' common practices of structuring hybrid transactions to organize technology exchange.

2.2 Licensing combination

In developing our model, we adhere to the "transactional value" approach proposed by Zajac and Olsen (1993) and conceive licensing as a cooperative dyad between two interdependent parties whose aim is to maximize the value of partnering. When drawing up a license, the parties choose the exchange structure that maximizes the joint value of both licensor and licensee and guarantees the success of the knowledge transfer. The adoption of this view has two main implications. Firstly, in terms of the partners' cooperation, there are conditions when the joint value maximization is not reached through standard licensing. Although the licensing contract per se, through the provision of contractual clauses and payment schemes, provides financial and economic incentives for exchanging "tightly packaged technology", it might not be effective in transferring tacit and specific knowledge. Unlike other partnerships, licensing does not entail the use of collaborative mechanisms for knowledge sharing, partners' interaction and communication. We argue that in response, firms draw up complex contracts combining licensing with other inter-firm collaboration forms as a means to integrate technology transfer beyond the proprietary knowledge elicited in the contract.

Secondly, conceiving licensing as a dyad between interdependent partners reveals the importance of taking into account the perspective of both licensor and licensee in explaining how the technology exchange is structured.

In order to provide a detailed analysis of different licensing combinations, we focus on two specific types of partnership to be coupled with licensing: R&D collaboration contracts and minority equity links.

Contractual research partnerships are project-based collaborations that span a medium-term time period. For instance in the pharmaceutical industry, they last on average between four and eight years (DiMasi, Hansen, & Grabowski, 2003). The parties usually agree to act collaboratively, share common goals toward the development and commercialization of a specific technology. They can either pool funds for co-developing and co-marketing the technology; or the joining party can buy into the project and finance the subsequent development of the technology relying on its partner's technical competences. Project managers are appointed by both partners and are responsible for inter-firm communications and knowledge sharing. Usually, a management committee composed of two or more representatives of each party coordinates the partnership (Hagedoorn & Hesen, 2007). During the collaboration, inter-firm communication relies mainly on quarterly meetings, sharing of research facilities, extended visits by research personnel.

The above description highlights the link between licensing and R&D collaboration. Partners' collaboration in R&D activity favors knowledge transfer. The setting up of regular meetings and visits to partners' research facilities enable the parties to understand and exchange highly contextual and tacit knowledge that would be difficult to transfer through licensing alone. Further, the R&D collaboration eases inter-organizational learning: partners access each other's capabilities, enabling the licensee to efficiently internalize the licensor's skills relative to the licensed technology. Learning occurs along a knowledge depth dimension: working jointly on a specific project, partners collaborate along different stages of the development process (Prencipe, 2000). Finally, by pooling skills and resources, the parties are better able to cope with technological uncertainty. The licensee can rely on the licensor's skills and know-how during the exploitation of the licensed innovation.

Minority equity holdings, unlike R&D partnerships, are company-based collaborations. When one research partner invests a small stake in another company, "it is commonly granted representation on its partners' board" (Pisano, 1989, p.122). When combined with licensing[1], a minority equity stake serves two main functions. By acquiring part of the capital stock, the investing firm – usually the licensee – establishes a preferential long-term link to future projects with the licensor (Arora & Gambardella, 1990). It provides the investing partner with the opportunity to explore other promising new technologies beyond the one being licensed. The objective of the licensee is to keep in touch and acquire some familiarity with the research skills of the partner company. Unlike an R&D collaboration, where learning occurs along a knowledge depth dimension, in the case of a minority equity contract learning occurs along a knowledge breadth dimension: the licensee aims to acquire knowledge about a set of different projects/technologies. From the licensor's perspective, opening up its capital to the licensee is a way to access its partner's managerial skills as well as to raise additional funds for internal R&D activity. The second function of minority equity in supporting licensing is related to Pisano's view of minority equity as "token of good faith". The equity participation creates a common ownership structure, safeguarding both partners from opportunistic behavior (Pisano, 1989).

[1] In the context of licensing, the licensee usually acquires a share of the licensor's equity capital.

In the hypotheses presented in the next sections, two types of antecedents are taken into account to explain licensing combination and the different role of R&D and equity contracts in supporting inter-organization exchange. In line with prior studies on knowledge transfer (van Wijk, Jansen, & Lyles, 2008), and consistently with the "transactional value" approach (Zajac & Olsen, 1993), we suggest that the characteristics of the exchanged technology as well as the attributes of the dyad have an impact on licensing combination. In the following subsections, we theoretically ground the discussion of each type of antecedent and develop hypotheses, taking into consideration the perspective of both licensor and licensee.

3. RESEARCH HYPOTHESES

3.1 Knowledge features

The impact of knowledge features on inter-firm technology transfer has been a subject of a long tradition of scholarship. Great attention has been paid to the tacitness of the knowledge to be transferred, its embeddedness in context, its idiosyncrasy and specificity (Grant, 1996; Kogut, 1988; Reed & Defilippi, 1990; Simonin, 1999). Findings have highlighted the negative impact of such characteristics on technology transfer: firms are hindered in their capability to share knowledge and need to resort to mechanisms easing partners' interaction and communication. Notwithstanding their importance to technology transfer, licensing literature has paid less attention to the features of the knowledge underlying the transaction and how such attributes impact the ways firms leverage licensing. To test the relationship, we focus on two main knowledge attributes: the development stage of the licensed innovation and its specificity.

3.1.1 Early stage technology

Previous empirical studies provide evidence of a frequent recurrence to *ex-ante* licensing: the licensor transfers a prospective technology to the licensee (Anand & Khanna, 2000; Arora et al., 2001a). In many industries, especially technology-intensive ones, firms exchange technologies at an embryonic stage of development. This trend has been explained in terms of either locking proprietary rights over a rising technology or accessing new technological domains that are key for the future competitive advantage of the licensee (Pisano, 2006; Roijakkers & Hagedoorn, 2006). From the licensor's perspective, selling an embryonic technology represents a way to guarantee its technological leadership or to access financial and complementary assets to further develop and market a new technology (Lichtenthaler, 2008; Teece, 1986).

Despite its frequent recurrence, licensing an innovation at an embryonic stage of development implies a non-trivial technology transfer process. First, the exchanged knowledge is frequently characterized by high degrees of ambiguity: the linkages and interactions between the underlying elements composing the technology are not completely defined and the commercial applications of the technology are still unknown (Simonin, 1999). The further development of the licensed innovation is likely to require high levels of experimentation and tinkering and the licensee to be dependent on the licensor to fully understand and internalize the technology (Somaya et al., 2010). Second, licensing over an embryonic technology implies that knowledge transfer is highly dependent on tacit and context-specific information. Knowledge stickiness renders the transfer between partners costly and slow (Kogut & Zander, 1992; von Hippel, 1994). As outlined by von Hippel (1994), knowledge transfer might be hindered by the amount of information with non-zero transfer costs. The licensee has to draw upon a great deal of information with a non-zero transfer cost in order to advance the innovation development work. Consequently, the technology elicited in the contract, either in the form of patents or blueprints, is only one part of the transfer process. For the licensee to internalize the licensed innovation it is fundamental to interact with the licensor to access tacit and un-codified knowledge once the contract is signed.

Under such conditions, standard licensing is unlikely to be effective in maximizing the partners' joint value. The licensee has to rely on the licensor's competences to further develop the licensed innovation. Additionally, it might be difficult for partners to communicate and share sticky and contextual knowledge without appropriate coordination mechanisms and incentives. Finally, given the inherent uncertainty of R&D activity, partners are constrained in their ability to fully specify in the license contract the amount of information beyond patents and blueprints the licensor should provide to its partner.

We argue that when the licensed technology is at an early stage of development, the combination of licensing with an R&D collaboration is likely. Through its coordination mechanisms, the R&D partnership enhances the value partners can extract from their interaction. This type of combination eases the transfer of the tacit component, reinforces learning and guarantees access to licensor's skills, enabling the licensee to optimally internalize the exchanged technology.

We posit the following:

Hypothesis 1. When the licensed technology is at an early stage of development, partners will be more likely to choose a license combined with an R&D collaboration.

3.1.2 Knowledge specificity

Some technologies, in order to be commercialized, need specific investments by the licensee either in terms of R&D, or manufacturing capabilities or marketing programs. For instance, the development and launch of a new drug requires on average capital investments for a total of $800 million (DiMasi et al., 2003). Due to technology requirements, regulatory norms and market-segment characteristics, part of these investments cannot be easily redeployed to other products.

Past studies have focused on the hazards deriving from transaction-specific skills and assets. Pisano (1989) highlights the difficulties firms face in writing complete contracts if R&D activity has to be undertaken and shows the use of equity links as a way to support exchange. Similarly Kim, Somaya and Vonortas (2010) show that when specific investments are to be undertaken by the licensee, the contract is likely to include exclusivity clauses and equity mechanisms in order to protect both licensor and the licensee. The licensee's minority equity participation creates a common ownership structure safeguarding both partners (Ahmadjian & Oxley, 2006; Deeds & Hill, 1999; Pisano, 1989).

We argue that, apart from transactional hazards, technology specificity renders stand-alone licensing ineffective for two main reasons. First, from the licensee's perspective, the undertaking of specific investments leads to the development of knowledge, skills and assets specific to the licensor's technology. These might be used to perform technologically similar projects in the future. It might be key for the licensee to guarantee access to similar future promising technologies of the licensor's technology base. Indeed, equity participation allows the licensee to exploit this long-term link to redeploy past investments in specific know-how and skills in future projects related to similar promising innovations of its partner's technology base.

Second, knowledge exchange through licensing does not guarantee an even distribution of information between partners. For instance, the licensor might possess more information about the commercial potential of the exchanged innovation than does the licensee. Therefore, by having a place on the board, the information flows is facilitated, providing the licensee with access to strategic information about the licensed technology.

We posit the following:

Hypothesis 2. When the licensed technology requires skills and asset-specific investments for its commercial exploitation, partners will be more likely to combine the license with a minority equity participation on the part of the licensee.

3.2 Dyad features

The adoption of the "transactional value" perspective highlights the high interdependence between the licensor and the licensee in technology exchange. Hence, in order to explain licensing combination, it is crucial to consider the attributes of the dyad and how they impact on firms' optimal combination choice. Specifically, three main characteristics are taken into account: the technological gap between partners, the licensee's unfamiliarity with the licensor's specific technology and the competence gap between licensor and licensee. The first and third constructs make it possible to distinguish between partners' diversity in terms of competences across technological domains as well as in terms of product and commercialization skills. Differently, the licensee's unfamiliarity with the licensor's technology captures whether the licensee lacks specific technical skills in order to receive and master its partner's knowledge.

3.2.1 Partners' technological diversity

In recent literature there is consensus on the importance of partners' technological profiles in determining the costs of technology transfer (van Wijk et al., 2008). If, on the one hand, differences in partners' knowledge bases are a source of knowledge creation; on the other, they represent a threat to partnering (Nooteboom, Vanhaverbeke, Duysters, Gilsing, & Vandenoord, 2007). The recombination of different resources might in fact lead to innovative outputs. However, when the distance between partners is excessive, cooperation is inhibited due to the lack of a common technological base in which to ground resource recombination (Colombo, 2003). The skills gap impedes learning and knowledge integration.

In the licensing context, the partners' technological diversity has been shown to be a cost rather than an opportunity. For instance, Kim and Vonortas' (2006) empirical investigation highlights that the likelihood of two partners forming a license is negatively related to their technological distance. Different technology specializations increase the learning cost the licensee has to bear in order to master and implement the licensed technology. Due to its different set of competences in distant technological fields, the licensee is limited in its capability to receive the licensor's knowledge (Cassiman & Veuglers, 2006). Moreover, the licensor might be required to implement some modifications to the technology in order to render it transferable.

Under such conditions, we posit that licensing needs to be integrated with other forms of collaboration in order to make technology transfer effective. Specifically, since partners lack a common technological base, R&D collaboration might represent a viable solution. By favoring interaction and learning about the licensed project, it bridges the partners' complementary knowledge bases, enabling the licensee to develop the licensed technology effectively.

As argued before, the interaction through licensing with a partner mastering different technological fields might also represent an opportunity. Access to a different set of competences is a way for the recipient firm to diversify its knowledge base, enter new technological domains and add new combinations to its current knowledge endowment. Therefore, the licensee might be willing to access its partner's technological domains beyond the scope of the licensed innovation and establish a preferential link to future projects that might represent an important source of innovation. Indeed, we argue:

Hypothesis 3a. The higher the technological diversity between the licensor and the licensee, the more likely it is that the license will be combined with an R&D collaboration.

Hypothesis 3b. The higher the technological diversity between the licensor and the licensee, the more likely it is that the license will be combined with a minority equity participation on the part of the licensee.

3.2.3 Unfamiliarity with licensor's technology

Technology transferability is favoured by the possession of related skills by the recipient firm (Cassiman & Veuglers, 2006; Cohen & Levinthal, 1990). As argued by Simonin (1999: p. 601): "for a knowledge seeker, prior experience with a given knowledge base predetermines the level of familiarity and comfort with both information content and context, and thus favours the transferability of knowledge". In the context of licensing, we argue that the capability of the licensee to absorb and integrate the licensed innovation with its knowledge endowment is dependent on the familiarity it has with the licensor's technology (Mowery et al., 1996). Unlike technological diversity, which is related to partners' dissimilarities along a set of technological domains, familiarity is related to the licensor's specific technology and the licensee's awareness of it. On the one hand, a company that decides to in-license a patent, having cumulated prior knowledge about the licensor's technological base through patent citations, is likely to possess the relevant skills needed to exploit the acquired technology. In contrast, when a company decides to in-license a technology, valuing its relevance to R&D strategy but lacking any prior specific experience, it might lack the technical competences to fully exploit it. The codified descriptions provided by the licensed patents embody only a partial explanation on how to proceed further.

We argue that unfamiliarity with the licensor's technological base threatens technology transfer effectiveness. Accessing the market through standard licensing might be sup-optimal for both partners: the licensee is limited in its capability of experimenting with the licensor's technology, putting the successful commercialization of the licensed innovation at risk. Under such conditions, we posit that licensing is likely to be coupled with an R&D collaboration. The latter supports the former by favouring learning and knowledge accumulation. By collaborating with the licensor in further developing the licensed technology, the licensee can fill the deficiencies and cumulate relevant skills to those of the licensor, reinforcing its ability to assimilate and apply the licensed innovation.

Hypothesis 4: If the licensee is unfamiliar with the licensor's technology base, the more likely it is that the license contract is combined with an R&D collaboration.

3.2.4 Vertical licensing

The licensing literature distinguishes between horizontal and vertical licenses (Anand & Khanna, 2000). A vertical license occurs between two organizations that, at least under the parameters of the license contract, engage in relatively distinct sets of activities along the industry value chain. In vertical licensing, companies located in the upstream pole of the industry value chain out-license their technology to companies located in the downstream pole. For instance, in many industries technology-based firms are understood to be originators of technology, which is eventually brought to the marketplace by partners with extensive production, marketing and distribution capabilities (Stuart et al., 2007). Horizontal licenses, unlike vertical agreements, involve partners operating along the same phases of the industry value chain.

Notwithstanding partners' specialization and interdependence, we argue that in the case of a vertical license stand-alone licensing is a sup-optimal choice. As the partners are engaged in different sets of activities along the industry value chain, knowledge integration is non-trivial. In industries where vertical licensing is a common practice, licensors are usually specialized in the early stages of technology development. For instance, biotech firms are focused on target identification and lead optimization (Pisano, 2006). All such phases require insights from disciplines such as molecular biology, cell biology, functional biology, etc. Licensees, instead, are specialized in downstream development phases, where the relevant disciplines are toxicology, clinical development, regulatory affairs, production and marketing (Pisano, 2006). The successful commercialization of the licensed technology requires tight knowledge integration and a continuous exchange of information throughout the development process, since each technical choice has implications for the others.

Thereby, it is fundamental for the licensee to rely on the licensor's competences in order to internalize the technology. Coupling the license with R&D activity might indeed support knowledge integration, bridging partners' specializations. It increases the likelihood of successful commercialization of a new profitable product, allowing the licensee to master the licensed technology and understand upstream processes as well as the licensor to anticipate downstream problems and requirements. The R&D collaboration favours information exchange and enables partners to work interdependently.

Moreover, we argue that the joint value maximization could be further reached through a minority equity participation on the part of the licensee. Given the partners' heterogeneity in terms of R&D and product-market competences, partners might have a common interest in establishing a long-term link beyond the project collaboration. The licensee might have an interest in its partner's technological base as a future source of innovations, beyond the scope of the licensed project. From the licensor's perspective, the establishment of a long-term link with the partner might be optimal as well. The licensee's equity participation provides access to managerial skills, market-product knowledge as well as downstream complementary assets.

Hence, if licensor and licensee belong to different phases of the industry value chain, it is likely that stand-alone licensing will not be effective.

Hypothesis 5a. When partners belong to different stages of the industry value chain – the license is a vertical one – partners will be more likely to choose a license combined with a R&D collaboration.

Hypothesis 5b. When partners belong to different stages of the industry value chain – the license is a vertical one – partners will be more likely to *choose a license combined with a minority equity participation on the part of the licensee.*

4. METHODS

4.1 Research setting

The research context of the study is the global biopharmaceutical industry over the period 1985-2004. The industry represents the ideal research setting in which to test the determinants of licensing combination because of its distributed innovation model, the centrality of inter-firm technology transfer and firms' strategic need for flexible contracts to manage different and concurrent partnerships. The industry accounts for a substantial share of inter-firm partnerships (Hagedoorn, 2002): since the mid-1970s it has experienced a growing pattern in the number of newly established R&D partnerships. This was especially true after the advent of biotechnology, which led to a radical change in the industry structure and the division of innovative labor (Arora & Gambardella, 1990). Due to the dispersion of knowledge among different actors and the rise of new technological areas, firms started to experiment with new forms of cooperation (Roijakkers & Hagedoorn, 2006). Firms are now engaged in a portfolio of flexible contract-based partnerships in order to access and acquire external specialized skills. Among the different forms, technology licensing accounts for the lion's share of technology exchanges (Anand & Khanna, 2000): small biotechnology companies out-license early stage compounds to large pharmaceutical companies conducting clinical trials, seeking market approval and finally manufacturing and commercializing new drugs (Stuart et al., 2007).

4.2 Data and sample

To test the research hypotheses, we compiled a dataset combining license data with firms' patent and market data. The license data are collected from Deloitte Recap Database. This database records a wide range of agreements in the global biopharmaceutical industry since 1985: mergers, license deals, settlement agreements, joint ventures, co-development agreements. A number of considerations led to building the research sample by drawing on Recap. First of all, it represents the most accurate and global information source on partnerships in the industry (Audretsch & Feldman, 2003; Schilling, 2009), making it possible to retrieve extensive and reliable data. It covers an extensive time period of analysis of about 30 years. Second, for each deal it provides copies of the material contracts filed per the requirements of the SEC and also provides some analysis of the contracts. The availability of original contracts allowed to collect detailed and objective information that other databases on alliances do not provide[2]. For instance, for each license agreement – whenever available – it provides access to additional contracts that were signed together with the license: R&D contracts, minority equity holding contracts, manufacturing agreements, marketing agreements, etc. Further, relative to the contract analysis, it provides information coded by industry experts. For instance, information relative to the development stage of the licensed technology is provided, as well as the therapeutic area of the deal, the type of investments planned by the acquiring party or the deal compensation scheme. Thus, the original contracts and their corresponding analyses provided a reliable and objective overview of each license partnership.

To build the research sample, the following criteria were applied in selecting the deal contracts from Recap: (i) the contract is a license agreement, (ii) the transaction

[2] For further information relative to alliance and license datasets, see Shilling (2008).

involves the transfer of "patent" or "technology", (iii) the original text of the contract is available. This led to an initial sample of 2018 licensing agreements. Next, only unilateral agreements were selected, excluding 378 cross-licensing deals. The exclusion of cross-licenses is due to the fact that they are usually negotiated when each of the two companies has patents that may read on the other's products or processes. They imply a bilateral technology exchange in order to guarantee both partners with freedom to operate in their internal innovative activity (Shapiro, 2001). Hence, the motives underlying their formation are different from those of a unilateral license (Colombo, 2003).

Finally, given the focus of the study on inter-firm partnerships, all licenses involving universities or governmental laboratories as technology partners were dropped. Although academic and governmental institutions are central actors in the market, we excluded them from the sample since unlike the private sector where profits and commercial success are the ultimate objective, university objectives are more diverse (Thursby, Jensen, & Thursby, 2001). For instance, the primary objectives of a technology transfer office from licensing usually comprise: attracting sponsored research funds, funding patent applications and generating royalties to fund internal academic research.

After the selection process, the research sample was composed of 815 license agreements.

Once the license data had been collected and coded, we matched the dataset with other information sources. The primary additional source of data was the National Bureau of Economic Research (NBER) dataset (Hall et al., 2001). By matching the names of both the licensor and licensee with assignees' names recorded in the NBER dataset, we could obtain the firms' patent portfolios and statistics related to their innovative activity. The further additional information sources were Biospace, Compustat and companies' websites. We matched the available information on the names of licensor and licensee with data on the firms' primary reference market – SIC codes – in order to detect whether partners were drug or biotech companies.

Due to missing values both in license and patent data, the final sample comprised 441 license agreements.

4.3 Measures

Dependent variable. According to our model, when signing a license, partners face two simultaneous choices: whether to combine the license with an R&D contract or not; whether to combine the license with a minority equity participation or not. In turn, the dependent variable is a bivariate one: it represents the probability of coupling the license with a R&D contract and the probability of coupling the license with a minority equity link on the part of the licensee.

Variables are coded from information provided in the license agreements and – wherever present – from R&D agreements and minority equity holding contracts related to the licenses. Other studies adopt a similar coding strategy for licensing-related variables (Anand & Khanna, 2000; Bessy & Brousseau, 1998a; Somaya et al., 2010).

Independent variables. Following the research hypotheses, we expect the *development stage* of the licensed technology to have an impact on the type of licensing combination. For each license deal, Recap provides a description of the licensed technology and its development phase. Drug development is a well-structured process, mainly consisting of three macro phases: discovery, clinical trials and regulatory approval (DiMasi et al., 2003). The discovery process ends with preclinical trials during which the compound undergoes laboratory and animal testing to assess safety and biological efficacy. After approval from the competent authorities for trials on humans, the candidate drug enters clinical trials. In order to capture the early stage nature of the licensed innovation, we coded a dummy variable – *early stage technology* – taking a value of 1 if the technology is licensed before preclinical trials; and 0, otherwise. During the coding process we relied on two industry experts to determine until which phase a compound could be classified as an early stage innovation.

In order to capture the degree of specificity of the licensed technology, two dummy variables were coded from the text of the license contracts: *R&D specific investments* and *marketing specific investments*. The former takes a value of 1 if the licensee is expected to undertake specialized R&D investments to evaluate, further develop and exploit the licensed technology. The latter captures whether technology specific investments in terms of market approval, advertising and marketing programs need to be set up to market the technology. As for the dependent variable, the variables were coded from information disclosed in the license or in the contracts coupled with it and cross-checking their reliability with the contract analyses provided by Recap. The focus is on specialized R&D and marketing investments, since their technology specificity is higher compared to those of other types of capital commitments such as manufacturing investments, which are more easily redeployable to other uses (Somaya et al., 2010).

Following previous studies (Branstetter & Sakakibara, 2002; Jaffe, 1986; Kim & Vonortas, 2006a; Sampson, 2007), we measure the diversity of partners' technological competences, namely *technological diversity*, by examining the extent to which partners patent in the same technological classes, i.e. patent classes. The choice of measuring partners' different technology specialization using patents is related to two main reasons. First, the industry appropriability regime is such that firms have incentives to protect their inventions through patents rather than recurring to other forms of protection (Cohen et al., 2000). Indeed, patents are good proxies of firms' knowledge bases (Griliches, 1990). Second, patents are categorized according to the underlying technology and not to the end product per se (Jaffe, 1986). Indeed, measuring technological diversity across patent classes makes it possible to understand the degree of dissimilarities between partners' knowledge bases. The variable is computed as follows:

$$\text{Technological diversity} = 1 - \frac{F_i F_j^{'}}{\sqrt{(F_i F_i^{'})(F_j F_j^{'})}} \text{ with } i \neq j$$

Vectors F_i and F_j are patents distributions across USPTO 3-digit patents classes of respectively licensee *i* and licensor *j* up to license year. The variable varies between 0 and 1, with value of 1 indicating the highest technological diversity between partners.

Unfamiliarity with the licensor's technology records whether the licensee is unfamiliar with the licensor's knowledge base. For constructing the variable we consider whether, before license year *t*, the licensee has cited the licensor's technology in its patents. The variable takes a value of 1 if the licensee has never cited the licensor's technology in its past patent applications; 0 otherwise. As it is well known in innovation literature, patent citations are a good indicator of firms' search process and inter-firm knowledge flows (Jaffe et al., 1993). Citations of the patents of firm A by the patents of firm B means that B is building on the technology of A and consequently that B is familiar with firm A's technology.

Vertical licensing is a dummy variable equal to 1 if partners belong to different phases of the industry value chain, i.e. if the licensor is a biotech company and the licensee is a drug company. The partners' industry classification was set according to SIC codes. The variable captures whether partners have different capabilities along the industry value chain. Traditionally, biotechnology firms are originators of technology, which is then brought to the marketplace by drug companies with extensive experience in managing the clinical trials and regulatory process (Rothaermel, 2001; Rothaermel & Deeds, 2004; Stuart et al., 2007).

Controls. In order to account for potential competing explanations of licensing combination, following prior literature we included a number of control variables.

Exclusive licensing is a dummy variable equal to 1 if the license contract is exclusive and 0 otherwise. The presence of exclusivity clauses has an influence on partners' cooperative behavior (Somaya et al., 2010), therefore we expect it to affect the choice of coupling the license with other contractual forms, acting as a substitute for equity investments.

We included a dummy to account for *international licensing*. Entering an international license is more challenging in terms of coordination and knowledge transfer, increasing the likelihood of coupling the license with R&D partnerships. The variable equals to 1 if the licensor and licensee are based in different regions, i.e. US, Europe and Japan; 0 otherwise.

For both licensor and licensee, the logarithmic transformation of total stock of patents applied for up to the license year is computed. The variables are proxies for *partners' inventive size*. According to prior literature, large and small firms leverage markets for technology differently. For instance, firms with large knowledge stocks usually out-license their patents to realize monetary benefits differently from smallscale companies that through technology licensing access downstream complementary assets and commercialize their inventions (Gans & Stern, 2003; Lichtenthaler, 2007a). Similarly, licensees with large knowledge stocks often access markets for knowledge with the goal of effectively exploiting their internal research activity and at the same time benefiting from their partners' technology specialization. They typically enter multiple concurrent forms of collaboration with their partner (Arora & Gambardella, 1990; Roijakkers & Hagedoorn, 2006). In turn, because of their impact on either the objectives or the ability to benefit from licensing, we expect partners' inventive size to influence the choice of licensing combination.

The variable *partners' past relationships* is defined as the number of prior licenses between the partners that were signed up to the license year. The variable proxies for the existence of informal and relational governance mechanisms based on reciprocity, trust, reputation and familiarity (Gulati, 1995a). We expect the presence of past ties to favour cooperation, reducing the partners' need to recur to licensing combination to support technology exchange.

Finally, a linear time trend variable, *time*, is included to control for possible growth in the number of agreements (Gulati, Lavie, & Singh, 2009; Hagedoorn et al., 2008) and in the gradual shift of firms' preferences between combined and stand-alone licenses.

4.4 Estimation strategy

Given the nature of the dependent variable, the empirical analysis is based on the estimates of a discrete choice model. When signing a license, partners face two simultaneous decisions: to couple the license with an R&D agreement, or not; to couple the license with a licensee's minority equity participation, or not. As mentioned before, following prior literature (Arora & Gambardella, 1990) we expect the two choices to be interrelated one another. Indeed, when estimating factors determining licensing combination, we need to take into account the relationship between R&D contracts and equity links and assess their potential joint incidence. A model making it possible to account for the joint incidence is the bivariate probit model (Cappellari & Jenkins, 2003). The general specification of the model is the following one:

$$y_1 = x_1^{'}\beta_1 + \varepsilon_1 \text{ where } y_1 = 1 \text{ if } y_1^* > 0\text{; 0 otherwise}$$
$$y_2 = x_2^{'}\beta_2 + \varepsilon_2 \text{ where } y_2 = 1 \text{ if } y_2^* > 0\text{; 0 otherwise}$$

$$E\left[\varepsilon_1 | x_1, x_2\right] = E\left[\varepsilon_2 | x_1, x_2\right] = 0$$

$$Var\left[\varepsilon_1 | x_1, x_2\right] = Var\left[\varepsilon | x_1, x_2\right] = 1$$

$$Cov\left[\varepsilon_1, \varepsilon_2 | x_1, x_2\right] = \rho$$

According to the model, error terms are distributed as a bivariate normal, each with zero average and variance-covariance matrix V, where V has values of 1 on the leading diagonal and correlations $\rho_{jk} = \rho_{kj}$ as off-diagonal elements (Greene, 2003).

It is important to recall that the correlation might reflect either jointness in the decision to couple the license with both R&D and equity contracts, or on the contrary, might reflect the presence of unobserved factors that affect both decisions. Therefore, model specification is fundamental to assess the relationship existing between the two simultaneous decisions. Omitting a variable influencing both the decision of coupling the license with an R&D agreement and the decision to couple the license with an equity contract would then be the cause of a correlation between the two. In order to account for unobserved heterogeneity caused by omitted variables, in model specification we draw on previous literature on both R&D partnerships and minority equity links in order to account for important factors being correlated with one or both decisions.

5. RESULTS

Before presenting the estimation results, it is worth describing some patterns in the data. The sample is composed of 441 license contracts. Of these: 51 percent are standard license agreements; 26 percent are license contracts combined with R&D agreements; 23 percent are license contracts coupled with minority equity contracts.

Table 6 provides an overview of the data and summary statistics.

Insert Table 6 about here

Approximately 65 percent of licenses are early stage and about 83 percent require investments in R&D activity for the successful commercialization of the licensed innovation. Additionally, about 90 percent of licenses are exclusive, 45 percent occur between partners belonging to different phases of the value chain, namely biotech and drug companies; finally, about 37 percent of licenses are international. As far the inventive size of licensors and licensees (measured in terms of patent stocks) is concerned, it is worth noting that on average licensee size is larger than licensor size, suggesting the well-established industry dynamic of small firms licensing their technologies to larger firms. Notwithstanding its focus on a single industry, the sample's descriptive statistics are similar to those of inter-industry data used in other studies (Annad and Khanna, 2000; Somaya et al., 2010).

Table 7 reports Pearson correlation coefficients. Correlation is low for most variables indicating that multicollinearity is not a problem in the analysis. Additionally, using STATA 10, variance inflated tolerance factors were calculated. All tolerance factors were close to one, indicating the absence of collinearity among variables.

Insert Table 7 about here

Table 8 reports the results of the bivariate probit analysis. In models 1-5 explanatory variables are step-wisely introduced. For the sake of simplicity, results discussion is based on the full model: model 5.

Insert Table 8 about here

Hypothesis 1 asserts that when the licensed technology is at an early stage of development, firms are likely to combine the license with an R&D agreement. In model 5, the coefficient of early stage licensing is positive and significant below the 5 percent level, supporting therefore hypothesis 1. The R&D agreement eases the transfer of sticky and contextual knowledge and guarantees licensor' support during technology exploitation.

Hypothesis 2 posits that it is likely that the license will be coupled with a minority equity participation on the part of the licensee if the licensed technology requires specific investments for its commercialization. Analyzing the equation relative to licensee's minority equity investment, we notice that estimated coefficients of the variable *R&D specific investment* are positive as expected but not significant at conventional levels. Instead, looking at the equation relative to R&D collaboration, the results show that technology-specific investments are related to R&D agreements rather than to equity links. We might conjecture that through an R&D contract, the licensee is better able to reduce sunk and technology-specific investments by securing access to licensor's research capabilities. As for the variable *marketing specific investment* in the equation relative to licensee's minority equity link, its coefficient is positive and significant below 1 percent level. The findings strongly support our idea that when the licensed technology is highly specific, it is likely to combine licensing with an equity link. In such a case the equity contract provides the licensee with access to its partner's technology base, thereby increasing the likelihood of redeploying specific skills and resources developed in commercializing the licensed innovation. In turn, hypothesis 2 is partially supported.

Hypothesis 3a conjectures that the higher the technological diversity between partners, the more likely they are to combine the license with an R&D collaboration. The hypothesis is weakly supported: the coefficient is positive but, in the full model, remains significant below the 10 percent level. Results weakly confirm the idea that the R&D collaboration bridges partners' knowledge bases, reinforcing the licensee's capability to master the licensed innovation. Hypothesis 3b, on the contrary, is not supported by results: technological diversity does not represent an opportunity to access and scout distant technological domains through an equity link.

Hypothesis 4 is supported. An inexperienced licensee is more likely to be reliant on the licensor's skills and know-how to exploit the licensed technology. Licensing needs to be supported with an R&D contract to guarantee the success of the transfer.

Results are supportive of Hypothesis 5a and 5b. In a vertical license, partners are more likely to combine licensing with both an R&D agreement and an equity participation. Issues of knowledge integration and access to complementary skills and resources lead firms to choose both an R&D collaboration and equity contract.

In analyzing the estimated correlation between the error terms we notice a positive sign, suggesting the existence of a complementary relationship between R&D agreement and licensee's equity contract. Notwithstanding the weak significance of the correlation coefficient, the result supports and enriches prior findings on the complementarity relation between R&D partnerships, providing evidence at the transaction level of analysis (Arora & Gambardella, 1990).

The results related to control variables are mixed. Under exclusive licensing, it is more likely that partners combine the license with an R&D agreement. Following Somaya, Kim and Vonortas' (2010) argument, the R&D collaboration might be a hostage the licensee provides to the licensor in exchange for exclusivity. Pertaining to partners' technology size, results confirm prior findings. Large licensors are likely to access the market through standard licensing. Such a strategy is a valuable tool to find markets for unexploited technologies and focus internal R&D activity (Gambardella et al., 2007). On the other hand, large licensees are more likely to leverage licensing to access proprietary knowledge and concurrently scout partners' technology base through equity links. Concerning partners' past ties, we surprisingly find that they do not have an effect on licensing combination choice. Finally, empirical evidence highlights the existence of a time trend in partners' license choice. The time coefficient is negative and significant in the case of R&D agreement, highlighting a shift in firms' preferences.

6. DISCUSSION AND CONCLUSIONS

In this study we departed from the traditional view of licensing as a spot market transaction for the exchange of proprietary knowledge and introduced the concept of licensing combination. Our work aimed at explaining the substantial heterogeneity in the ways firms access markets for knowledge through licensing, examining factors that drive partners to integrate a license contract with R&D partnerships. Drawing on licensing and R&D partnership literature and adopting the "transactional value" perspective, we identified two types of antecedents – knowledge and dyad features – to explain licensing combination and the role of R&D and equity contracts in supporting inter-organizational exchange.

Empirical results provided support for our theoretical predictions. As for the antecedents related to knowledge features, we find that both the development stage of the licensed technology as well as its specificity have an impact on firms' combination choice. The findings highlight the importance of R&D collaborations in supporting technology exchange, favouring the transfer of sticky and contextual knowledge and guaranteeing the licensee with access to licensor's skills and know-how. Interestingly, we find that when the exchanged knowledge is highly specific, the optimal combination is contingent on the type of specificity. If knowledge specificity is in terms of R&D investments, then partners choose to maximize their joint value by combining the license with an R&D collaboration. Instead, if specificity is not related to R&D activity, then minority equity participation by the licensee is the optimal mechanism to profit from licensing. Our findings show that a gap in partners' technological skills as well as market competences hinders licensing effectiveness. Considering technological skills, the results outline that either in the absence of a common knowledge set between partners or in case of the licensee's unfamiliarity with its partner's technology base, the exchange is to be supported through a collaboration in R&D. On the other hand, in the case of a competence gap due to companies' different specialization along the value chain, the partners' optimal choice is a combination of licensing with both R&D and equity contracts. In turn, empirical evidence supports our conjecture about the different role of R&D and equity contracts when combined with licensing.

Theoretically, the arguments and results of the study contribute to the literature on markets for technology and R&D partnerships. From the perspective of markets for ideas, we advance knowledge on the use of licensing to benefit from inter-firm partnering. Our study proposes a new conceptualization of licensing, well beyond the traditional view of a market-based transaction for the exchange of IP rights, enriching the recent literature on license optimal structuring (Bessy & Brousseau, 1998a; Brousseau, Coeurderoy, & Chaserant, 2007; Cebrian, 2009; Somaya et al., 2010). We provide evidence of different ways firms leverage licensing combination to maximize the benefits from accessing the market. Such identification is important in and of itself in the context of markets for technology, since it provides a micro detailed analysis of firms' licensing practices. However, it is also important since it highlights the centrality of tailoring *ad hoc* licensing agreements in order for firms to balance access to external resources with the acquisition and integration of skills into internal knowledge endowments. In many industries, technological convergence and vertical division of innovative labour have led firms to be part of networks of innovation (Powell et al., 1996). Firms are engaged in multiple and concurrent external ties. Thereby, given the importance of accessing external resources and optimally managing such relationships, it is key for firms to rely on flexible governance mechanisms guaranteeing a balance between resource access and resource accumulation. Thanks to our research design, we contribute to the understanding of different types of licensing combination, highlighting firms' cooperative use of markets for technology. On the base of our quantitative results as well as leveraging the in-depth insights of our qualitative review of licensing deals we propose four types of licensing combination: 1) Stand-alone licensing; 2) R&D licensing; 3) Equity licensing; 4) R&D and equity licensing.

The first type embodies the traditional view of licensing: a market exchange for proprietary knowledge. A relevant example in our dataset is provided by the license agreement between Aventis and Zymogenetics in the hematology therapeutic area. A large pharmaceutical company sold its patents to a biotech company that in the process of re-establishing itself as an independent company, aimed through the agreement to enlarge its project-portfolio and R&D pipeline. The second type of licensing combination represents the coupling of licensing with an R&D collaboration. This latter allows the licensee to access and optimally internalize the licensed technology and the licensor to secure the success of the transfer. Indeed, the license partnership between ICOS and Abbott in the oncology therapeutic area is an example of how partners exploited markets for ideas through an R&D collaboration to identify and optimize therapeutic agents small molecules in the field. The third type depicts the combination of licensing with minority equity participation by the licensee. This case represents the situation where the firms' partnering value is linked both to license-based resources as well as to company-based resources. For instance, due to the importance of Genelabs' knowledge in the infectious diseases therapeutic area to Glaxo's technology strategy, the parties entered an equity capital contract: Glaxo became a shareholder of Genelabs' equity capital. At the same time, Genelabs out-licensed its technology and patents to Glaxo in order for the latter to develop and commercialize a vaccine against the Hepatitis C virus. Finally, the last type of licensing combination represents a situation in which both R&D and equity links integrate the exchange to maximize partners' joint value. An example is the agreement between Neurogen and Merck, in which the latter paid $15 million as upfront fee to access Neurogen's patents and know-how. The partners integrated the license with an R&D agreement with the goal of pooling their competences to further develop an embryonic technology related to the treatment of pain (vanilloid receptor – VR1 –). Additionally, Merck purchased shares of Neurogen for about $15 million to monitor its partner's research activities in a growing therapeutic area such as the treatment of pain.

We further contribute to the literature by providing a dynamic view of licensing. Prior research has focused on the analysis of a focal firm's perspective, neglecting the fact that a technology exchange is the result of a bilateral negotiation between partners with different strategic and economic expectations. The adoption of the perspective of both licensor and licensee provides a complete framework to understand firms' choice in structuring technology exchange and more importantly highlights the cooperative nature of markets for ideas.

Finally, the study advances by a few steps the R&D partnership literature. Our contribution is twofold. Firstly, the analysis of licensing combination with R&D and equity contracts sheds further light on the so-called "hybrid" transaction forms lying along the market-hierarchy continuum. Prior studies have mainly focused on the market-hierarchy dichotomy, overlooking firms' common practices of structuring hybrid transactions to exchange technology. Our research design, by relying on original license agreements, allowed to deepen our understanding of hybrid transactions with a fine-grained analysis of partners' choices. The study's focus on licensing and the contingent factors leading firms to resort to R&D contracts and equity links provides with an explanation of the heterogeneity in license partnering forms. An R&D collaboration, through its coordination mechanisms, creates a common knowledge ground in which to base technology transfer. Instead, minority equity serves to access a broader set of resources and competences well beyond the licensed project, creating a long-term link between partners.

The paper also makes a contribution towards managerial practice. From a practitioner standpoint, the analysis of optimal licensing strategy to access markets for knowledge is of significant importance, given the economic and strategic stakes associated with it. As outlined by previous studies, accessing external knowledge is fruitful for firms' innovation strategy, positioning and time to market (Arora et al., 2001a; Chesbrough, 2003). Therefore, the analysis and proposed classification scheme provide managers with an understanding of the optimal combination strategy to leverage licensing contingent on technology and dyad specific factors.

We acknowledge a number of limitations of the study. While we were able to explain when licensing combination occurs and how firms couple the license contract, we did not relate firms' combination choice to any performance measure either at firm or project level. Future research could attempt to relate the choice of license combination to the research outcome of the partnership or differently to the innovative performance of the acquiring firm. This would clarify the link between license contract structuring and performance, a stream of research that as of today has received little attention.

The study provides a framework of analysis to understand firms' use of licensing to access and cumulate external resources and skills. Future research might extend our framework including into the analysis universities and governmental laboratories. As mentioned before, these play a key role in markets for ideas, as they are core sources of basic knowledge. Indeed, future work should start investigating how licensing is leveraged when universities and government institutions are involved as technology partners.

The findings support our research hypotheses; however, we must acknowledge that our focus on the biopharmaceutical industry raises questions about the generalizability of the study to other research settings. The industry has several unique features that differentiate it from other technology-intensive industries. Among the unique characteristics, we mention the following: a risky and long product development process, the presence of a regulatory approval process to access the market and the importance of scientific knowledge in R&D activity. Despite these unique attributes, we believe our results might be extended beyond this specific research setting since inter-firm cooperation through licensing is at the core of firms' strategy in other technology-intensive industries. For instance, in the electronics and information technology industries, the complexity of technologies and the complementarity of innovative inputs require intensive collaboration for technology transfer, inducing firms to combine licensing with other partnerships (Hagedoorn et al., 2008). Future research could assess the validity of our analysis by testing it in different industry settings.

Finally, we restricted our analysis to R&D and licensee's minority equity contracts neglecting the use of other forms of collaborations such as manufacturing or co-marketing agreements to integrate licensing. Although our choice made it possible to understand technology related factors influencing firms' use of licensing. However, we believe future research might benefit further by including other factors and consequently other forms of collaborations.

References

Aghion, P., & Tirole, J. 1994. On the Management of Innovation. ***Quarterly Journal of Economics***, 109(4): 1185-1207.

Ahmadjian, C., & Oxley, J. 2006. Using Hostages to Support Exchange: Dependence Balancing and Partial Equity Stakes in Japanese Automotive Supply Relationships. ***Journal of Law, Economics, and Organization***, 22(1): 213-233.

Anand, B., & Khanna, T. 2000. The structure of licensing contracts. ***Journal of Industrial Economics***, 48(1): 103-134.

Arora, A. 1996. Contracting for tacit knowledge: the provisions of technical services in technology licensing contracts. ***Journal of Development Economics***, 50(2): 233-256.

Arora, A. 2003. Licensing the market for technology. ***Journal of Economic Behavior & Organization***, 52(2): 277-295.

Arora, A., Fosfuri, A., & Gambardella, A. 2001. ***Markets for technology: The economics of innovation and corporate strategy***. Cambridge, Massachusetts: The MIT Press.

Arora, A., & Gambardella, A. 1990. Complementarity and external linkages: the strategies of the large firms in biotechnology. ***Journal of Industrial Economics***, 38(4): 361-379.

Arora, A., & Gambardella, A. 2010. Ideas for rent: an overview of markets for technology. ***Industrial and Corporate Change***, 19(3): 775-803.

Audretsch, D., & Feldman, M. 2003. Small-Firm Strategic Research Partnerships: The Case of Biotechnology. ***Technology Analysis & Strategic Management***, 15(2): 273-288.

Bessy, C., & Brousseau, E. 1998. Technology licensing contracts features and diversity. ***International Review of Law and Economics***, 18: 451-489.

Branstetter, L. G., & Sakakibara, M. 2002. When do research consortia work well and why? Evidence from Japanese panel data. ***The American Economic Review***, 92(1): 143-159.

Brousseau, E., Coeurderoy, R., & Chaserant, C. 2007. The governance of contracts: Empirical evidence on technology licensing agreements. ***Journal of Institutional and Theoretical Economics***: 205-235.

Cappellari, L., & Jenkins, S. 2003. Multivariate probit regression using simulated maximum likelihood. ***The Stata Journal***, 3: 221-222.

Cassiman, B., & Veuglers, R. 2006. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. ***Management Science***, 52(1): 68-82.

Cebrian, M. 2009. The structure of payments as a way to alleviate contractual hazards in international technology licensing. ***Industrial and Corporate Change***, 18(6): 1135-1160.

Chesbrough, H. 2003. ***Open Innovation: the new imperative for creating and profiting from technology***. Boston: Harvard Business School Press.

Choi, J. P. 2001. Technology transfer with moral hazard. ***International Journal of Industrial Organization***, 19: 249-266.

Cohen, W., Nelson, R., & Walsh, JP. 2000. Protecting their intellectual assets: appropiability conditions and why U.S. manufacturing firms patent or not. ***NBER Working Paper n. 7552***.

Cohen, W. M., & Levinthal, D. 1990. Absorptive capacity: A new perspective on learning and innovation. ***Administrative Science Quarterly***, 35(1): 128-152.

Colombo, M. G. 2003. Alliance form: a test of the contractual and competence perspectives. ***Strategic Management Journal***, 24(12): 1209-1229.

Deeds, D., & Hill, C. 1999. An examination of opportunistic action in research alliances: evidence from the biotechnology industry. ***Journal of Business Venturing***, 14(2): 141-163.

DiMasi, J. A., Hansen, R. W., & Grabowski, H. G. 2003. The price of innovation: new estimates of drug development costs. ***Journal of Health Economics***, 22(2): 151-185.

Fosfuri, A. 2006. The licensing dilemma: understanding the determinants of the rate of technology licensing. ***Strategic Management Journal***, 27(12): 1141-1158.

Gallini, N., & Wright, B. 1990. Technology transfer under asymmetric information. ***RAND Journal of Economics***, 21(1): 147-160.

Gambardella, A., Giuri, P., & Luzzi, A. 2007. The market for patents in Europe. ***Research Policy***, 36: 1163-1183.

Gans, J. S., & Stern, S. 2003. The product market and the market for ideas: commercialization strategies for technology entrepreneurs. ***Research Policy***, 32: 333-350.

Grant, R. M. 1996. Toward a knowledge-based theory of the firm. ***Strategic Management Journal***, 17(Special Issue: Knowledge and the firm): 109-122.

Greene, W. 2003. ***Econometric Analysis***. Upper Saddle River, New Jersey: Prentice Hall.

Griliches, Z. 1990. Patent statistics as economic indicators: A survey. ***Journal of Economic Literature***, 28(4): 1661-1707.

Gulati, R. 1995. Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. ***Academy of Management Journal***, 38(1): 85-112.

Gulati, R., Lavie, D., & Singh, H. 2009. The nature of partnering experience and the gains from alliances. ***Strategic Management Journal***, 30(11): 1213-1233.

Hagedoorn, J. 1993. Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectoral differences. ***Strategic Management Journal***, 14: 371-395.

Hagedoorn, J. 2002. Inter-firm R&D partnerships: an overview of major trends and patterns since 1960. ***Research Policy***, 31: 477-492.

Hagedoorn, J., Lorenz-Orlean, S., & van Kranenburg, H. 2008. Inter-firm technology transfer: partnership-embedded licensing or standard licensing agreements? ***Industrial and Corporate Change***, 18(3): 529-550.

Hagedoorn, J., & Hesen, G. 2007. Contract Law and the Governance of Inter-firm Partnerships- An analysis of different forms of partnering and their contractual implications. ***Journal of Management Studies***, 44(3): 342-365.

Hall, B., Jaffe, A., & Trajtenberg, M. 2001. The NBER patent citations data file: lessons, insights, and methodological tools. ***NBER Working Paper***, 8498.

Jaffe, A. 1986. Technological opportunity and spillovers of R&D: evidence from firms' patents, profits and market value. ***The American Economic Review***, 76(5): 984-1001.
Jaffe, A., Trajtenberg, M., & Henderson, R. 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. ***The Quarterly Journal of Economics***, 108(3): 577-598.
Kim, Y., & Vonortas, N. 2006. Technology licensing partners. ***Journal of Economics and Business***, 58(4): 273-289.
Kogut, B. 1988. Joint ventures: theoretical and empirical perspectives. ***Strategic Management Journal***, 9: 319-332.
Kogut, B., & Zander, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. ***Organization Science***, 3(3): 383-397.
Laursen, K., Leone, M. I., & Torrisi, S. 2010. Technological exploration through licensing: new insights from the licensee's point of view. ***Industrial and Corporate Change***, 19(3): 871-897.
Lichtenthaler, U. 2007. Corporate technology out-licensing: Motives and scope. ***World Patent Information***, 29(2): 117-121.
Lichtenthaler, U. 2008. Leveraging technology assets in the presence of markets for knowledge. ***European Management Journal***.
Lichtenthaler, U., & Ernst, H. 2009. Technology licensing strategies: the interaction of process and content characteristics. ***Strategic Organization***, 7(2): 183-221.
Mowery, D. C., Oxley, J. E., & Silverman, B. S. 1996. Strategic alliances and interfirm knowledge transfer. ***Strategic Management Journal***, 17: 77-91.
Nooteboom, B., Vanhaverbeke, W., Duysters, G., Gilsing, V., & Vandenoord, A. 2007. Optimal cognitive distance and absorptive capacity. ***Research Policy***, 36(7): 1016-1034.
Oxley, J. 1989. Appropriability Hazards and Governance in Strategic Alliances: a transaction cost approach. ***Journal of Law Economics & Organization***, 13(2).
Palomeras, N. 2007. An analysis of pure-revenue technology licensing. ***Journal of Economics and Management Strategy***, 16(4): 971-994.
Pisano, G. 1989. Using Equity Participation to Support Exchange: Evidence from the Biotechnology Industry. ***Journal of Law Economics & Organization***, 5(1): 109-126.
Pisano, G. 2006. Can science be a business? Lessons from biotech. ***Harvard Business Review***, 84(10): 114-125.
Powell, W. W., Koput, K., & Smith-Doerr, L. 1996. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. ***Administrative Science Quarterly***, 41: 116-145.
Prencipe, A. 2000. Breadth and depth of technological capabilities in CoPS: the case of the aircraft engine control system. ***Research Policy***, 29: 895-911.
Reed, R., & Defilippi, R. J. 1990. Casual ambiguity, barriers to imitation, and sustainable competitive advantage. ***The Academy of Management Review***, 15(1): 88-102.
Roijakkers, N., & Hagedoorn, J. 2006. Inter-firm R&D partnering in pharmaceutical biotechnology since 1975: Trends, patterns, and networks. ***Research Policy***, 35(3): 431-446.

Rothaermel, F. T. 2001. Incumbent's advantage through exploiting complementary assets via interfirm cooperation. ***Strategic Management Journal***, 22(6-7): 687-699.

Rothaermel, F. T., & Deeds, D. L. 2004. Exploration and exploitation alliances in biotechnology: a system of new product development. ***Strategic Management Journal***, 25(3): 201-221.

Sampson, R. C. 2007. R&D alliances and firm performance: the impact of technological diversity and alliance organization on innovation. ***Academy of Management Journal***, 50(2): 364-386.

Schilling, M. A. 2009. Understanding the alliance data. ***Strategic Management Journal***, 30(3): 233-260.

Shapiro, C. 2001. Navigating the patent thicket: cross licenses, patent pools, and standard setting, ***Innovation policy and the economy***, Vol. Volume 1: MIT Press.

Simonin, B. 1999. Ambiguity and the process of knowledge transfer in strategic alliances. ***Strategic Management Journal***, 20(7): 595-623.

Somaya, D., Kim, Y., & Vonortas, N. S. 2010. Exclusivity in licensing alliances: using hostages to support technology commercialization. ***Strategic Management Journal***, 32(2): 159-186.

Stuart, T., Ozdemir, S., & Ding, W. 2007. Vertical alliance networks: The case of university–biotechnology–pharmaceutical alliance chains. ***Research Policy***, 36(4): 477-498.

Teece, D. J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. ***Research Policy***, 15: 285-305.

Thursby, J., Jensen, R., & Thursby, M. 2001. Objectives, characteristics and outcomes of university licensing: a survey of major U.S. universities. ***Journal of Technology Transfer***, 26(1): 59-72.

van Wijk, R., Jansen, J. J. P., & Lyles, M. A. 2008. Inter and intra-organizational knowledge transfer: a meta-analytic review and assessment of its antecedents and consequences. ***Journal of Management Studies***, 45(4): 830-853.

von Hippel, E. 1994. "Sticky information" and the locus of problem solving: implications for innovation. ***Management Science***, 40(4): 429-439.

Zajac, J., & Olsen, C. 1993. From transaction cost to transaction value analysis: implications for the study of interorganizational strategies. ***Journal of Management Studies***, 30(1): 131-145.

APPENDIX: MAIN TABLES

Table 1. Descriptive statistics

	Source	N	Mean	s.d.	Min	Max
Dependent variables						
R&D collaboration	Recap	441	0.26	0.44	0	1
Licensee's minority equity	Recap	441	0.23	0.42	0	1
Main independent variables						
Early stage technology	Recap	441	0.60	0.49	0	1
R&D investments	License	441	0.83	0.37	0	1
Marketing investments	License	441	0.82	0.39	0	1
Unfamiliarity with licensor's technology	NBER	441	0.97	0.14	0	1
Technological diversity	NBER	441	0.49	0.34	0	1
Vertical licensing	Compustat	441	0.46	0.50	0	1
Control variables						
Exclusive licensing	License	441	0.92	0.27	0	1
International licensing	License	441	0.38	0.49	0	1
Previous ties	Recap	441	1.10	0.36	1	3
Licensor's patent stock	NBER	441	296.93	1092.36	0	13257
Licensee's patent stock	NBER	441	550.59	1126.05	0	11086
Time		441	1995.84	4.62	1985	2004

Table 2. Correlation matrix

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. R&D collaboration	1.00											
2. Licensee's minority equity	**0.16**	1.00										
3. Early stage technology	**0.22**	0.07	1.00									
4. R&D investments	**0.10**	0.06	**0.15**	1.00								
5. Marketing investments	0.01	0.06	-0.09	-0.05	1.00							
6. Unfamiliarity with licensor's technology	0.09	0.04	0.01	0.06	-0.02	1.00						
7. Technological diversity	**0.14**	0.07	0.03	0.02	0.02	0.05	1.00					
8. Vertical licensing	**0.22**	**0.19**	0.07	0.00	-0.03	0.01	0.08	1.00				
9. Exclusive licensing	**0.15**	0.08	**-0.14**	0.05	**0.21**	0.08	0.01	**0.12**	1.00			
10. International licensing	-0.08	**-0.10**	0.03	**0.10**	0.08	-0.05	-0.06	0.08	0.04	1.00		
11. Past ties	-0.03	-0.06	0.03	0.00	-0.03	-0.05	**-0.14**	-0.09	0.01	-0.06	1.00	
12. Log(licensor's patent stock)	**-0.31**	**-0.15**	**-0.30**	-0.01	0.01	**-0.16**	**-0.20**	**-0.30**	**-0.14**	-0.01	**0.14**	1.00
13. Log(licensee's patent stock)	**0.16**	**0.23**	**0.11**	-0.01	-0.03	0.01	0.05	**0.43**	**0.11**	-0.06	-0.00	**-0.24**

Note: Correlation coefficients in bold are significant at a 5% level.

Table 3. Bivariate probit estimates: determinants of licensing combination with R&D and equity contracts

	Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**	
	R&D	Equity	R&D	Equity	R&D	Equity	R&D	Equity	R&D	Equity
Main independent variables										
Early stage technology	**0.44*** (0.157)	0.13 (0.154)	**0.39**** (0.163)	0.11 (0.157)	**0.38**** (0.162)	0.11 (0.157)	**0.38**** (0.164)	0.11 (0.157)	**0.41**** (0.164)	0.11 (0.159)
R&D investments			**0.46**** (0.223)	0.21 (0.200)	**0.45**** (0.220)	0.20 (0.200)	**0.46**** (0.222)	0.20 (0.201)	**0.47**** (0.223)	0.23 (0.199)
Marketing investments			0.19 (0.580)	**4.03***** (0.208)	0.19 (0.626)	**4.02***** (0.203)	0.19 (0.621)	**4.36***** (0.199)	0.26 (0.550)	**4.40***** (0.231)
Technological diversity					**0.42**** (0.214)	0.11 (0.210)	**0.40*** (0.215)	0.11 (0.209)	**0.38*** (0.217)	0.09 (0.208)
Unfamiliarity licensor's tech							**4.57***** (0.253)	-0.01 (0.613)	**4.52***** (0.280)	-0.06 (0.600)
Vertical licensing									**0.43***** (0.161)	**0.34**** (0.161)
Control variables										
Exclusive licensing	1.40*** (0.455)	0.36 (0.304)	1.38*** (0.466)	0.26 (0.310)	1.46*** (0.465)	0.27 (0.308)	1.46*** (0.470)	0.27 (0.309)	**1.45***** (0.465)	0.23 (0.307)
International licensing	-0.17 (0.149)	-0.28* (0.148)	-0.19 (0.151)	-0.30** (0.150)	-0.16 (0.150)	-0.30** (0.150)	-0.14 (0.151)	-0.30** (0.150)	-0.20 (0.152)	**-0.35**** (0.149)
Log(licensor's patent stock)	-0.15*** (0.036)	-0.07** (0.032)	-0.15*** (0.036)	-0.07** (0.032)	-0.14*** (0.036)	-0.07** (0.032)	-0.13*** (0.037)	-0.07** (0.034)	**-0.12***** (0.038)	-0.06 (0.034)
Log(licensee's patent stock)	0.06** (0.028)	0.10*** (0.027)	0.06** (0.028)	0.10*** (0.027)	0.06** (0.028)	0.10*** (0.027)	0.06** (0.028)	0.10*** (0.027)	0.03 (0.030)	**0.08***** (0.030)
Past ties	-0.04 (0.257)	-0.29 (0.211)	-0.01 (0.248)	-0.27 (0.207)	0.03 (0.258)	-0.26 (0.210)	0.03 (0.263)	-0.26 (0.210)	0.07 (0.263)	-0.21 (0.211)
Time	-0.06*** (0.017)	0.02 (0.015)	-0.07*** (0.018)	0.02 (0.015)	-0.07*** (0.018)	0.02 (0.015)	-0.07*** (0.018)	0.02 (0.015)	**-0.07***** (0.019)	0.02 (0.015)
Rho R&D-Equity	**0.19*** (0.097)		**0.18*** (0.098)		**0.18*** (0.098)		**0.18*** (0.098)		**0.17*** (0.098)	
Observations	441	441	441	441	441	441	441	441	441	441
Log-likelihood	-422.96	-422.96	-418.91	-418.91	-416.96	-416.96	-415.57	-415.57	-410.11	-410.11

Note: Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Constant terms omitted from the table.