Exploring the Boomerang Effect: The Role of Core Technologies and Uncertainty in Explaining the Use of the Grant-Back Clause in Technology Licensing

ABSTRACT

Licensing is one of the most commonly observed inter-firm contractual agreements. Drawing on the resource-based view of the firm and contract economics, we argue that the inclusion of a grant-back clause in licensing agreements emerges as a consequence of the licensor and licensee firms' requirements to balance the need to protect their technological resources with the need to learn through internal and external processes. We argue that licensing agreements are increasingly likely to contain a grant-back clause (i) the closer the licensed technology is to the core of the licensor's patent portfolio, and (ii) the higher the uncertainty of the licensed technology. In contrast, we conjecture decreasing likelihood of a grant-back clause, the closer the licensed technology is to the core of the licensee's patent portfolio. Technological uncertainty is conjectured to positively moderate the results both when the licensed technology is part of the core technology of the licensee and the licensor. We test our hypotheses using a sample of 404 licensed technologies over the period 1984-2004. We employ a hierarchical nested decision model to account for the inclusion of a grant-back clause in a licensing contract nested in the decision about which technologies to license out. We find broad support for our theoretical arguments.

Keywords: Grant-back Clause, Technology Licensing, Core Technology, Technological Uncertainty.

INTRODUCTION

The modern innovative firm operates in a world characterized by specialization advantages, and has many different inputs to its knowledge production (Pavitt, 1998). This implies that firms can achieve competitive advantage by outdoing competitors at combining knowledge from internal and external sources in the production of new and superior products (Kogut and Zander, 1992; Lavie, 2006). Licensing agreements are an important channel for knowledge exchange: Anand and Khanna (2000) suggest that: "Licensing…is one of only a few significant methods of technology transfer between firms, and one of the most commonly observed inter-firm contractual agreements."

However, even if there are large potential mutual gains from trading in knowledge, these transactions may not take place, because of the nature of the knowledge. If it is not well defined it cannot be specified exactly in a contract perhaps because the technology includes a strong tacit component. These characteristics make it cumbersome and costly for licensees to integrate the licensors' technology in their own activities (Ceccagnoli and Jiang, 2012), and also allow for opportunistic behavior that in turn limits its trade. Moreover, because of the impossibility of specifying a complete contract, trade in cutting-edge technologies may not take place because of the possibility it gives the licensee to develop the technology further and allow the licensee to overtake the licensor —the so-called "boomerang effect" (Van Dijk, 2000; Choi, 2002).

Nevertheless, as Arora and Gambardella (2010: 787) point out, the increased use of science in technological advances means that technological outcomes can be defined more clearly, and the development of simulation software is enabling codification of innovations, with the result that the transaction costs related to the licensing market have reduced in recent years. For example, reduced transaction costs have led to an increase in the value of the technology exchanges within

the Organisation for Economic Co-operation and Development (OECD) since the early 1990s (Ceccagnoli and Jiang, 2012). However, technology licensing is still not a priority for many high-tech firms (Arora and Gambardella, 2010) although some of the problems inherent in the licensing market can be overcome by well-designed contracts which include clauses that align the incentives of the trading parties. The strategic management literature suggests that, generally, contractual clauses are vital for aligning the interests of the parties in inter-firm relationships such as strategic alliances. In particular, they can enable transactions that require investment in specific assets by coordinating resources and mitigating the risk of opportunistic behavior (Poppo and Zenger, 2002; Hoetker and Mellewigt, 2009).

While technology licensing has been investigated in the economics (e.g., Gallini, 1984; Rockett, 1990 ; Arora and Fosfuri, 2003) and strategic management (e.g., Arora and Ceccagnoli, 2006; Fosfuri, 2006; Ceccagnoli and Jiang, 2012) literatures, the role played by specific clauses in licensing contracts has been mostly ignored. However**,** there are some exceptions. Hagedoorn and Hesen (2007) analyzes the types of clauses used in various contractual agreements, including licensing agreements, to assess typical contracting perspectives. Hagedoorn et al. (2009) scrutinize licensing to other firms, focusing on the conditions that lead firms to use standard licensing contracts or construct more elaborate partnership-embedded licensing agreements. Cebrién (2009) proposes an empirical model that includes options for royalties or fixed payments, or a combination of the two, through the inclusion of clauses relating to contractual hazards. Somaya et al. (2011) examines the conditions leading to licensing agreements including exclusivity clauses.

While this literature has added to our understanding of the functioning of technological licensing and licensing contracts, we still know very little about an important and often used

clause in licensing contracts: The grant-back clause.[1] In many cases that (potentially) involve dynamic effects of licensing on the competitiveness of the licensor in the innovation market (Choi, 2002), grant back clauses are essential. The grant-back clause "requires the potential licensee to agree to grant back to the patentee [i.e., the licensor] rights to improvement patents developed by the licensee that relate to the original patent as partial consideration for the license right" (Schmalbeck, 1975: 733). In this context, Leone and Reichstein (2012) show that licensees achieve more rapid innovation than comparable non-licensees. If the license includes a grant-back clause, this effect ceases to exist because the grant-back clause reduces the licensee's incentive to further develop the licensed technology. However, Leone and Reichstein's (2012) findings for grant-back clauses refer only to *pace* of innovation.

Thus, our knowledge of the contingencies that determine when the contracting parties agree to include a grant-back clause is limited. In this paper, we try to increase it by focusing on the factors that might explain the inclusion of a grant-back clause in a technology licensing agreement, as a result of negotiation between licensor and licensee. To our knowledge, this paper is unique in trying systematically to explain this phenomenon. We focus especially on the characteristics of the licensed technology in terms of similarities with the licensor's and licensee's knowledge bases and technical uncertainties about the scope, level and the quality of follow-on innovations.

We combine insights from the resource-based view (RBV) of the firm and contract economics to build theoretical arguments regarding the inclusion of grant-back clauses in technology licensing contracts. Our fundamental theoretical argument centers on the contracting firm's needing to balance protection of its technological resources—the basis of its competitive

[1] Caves et al. (1983) report that in their sample, 43% of firms' licensing agreements included a grant-back clause. In our sample 17% of the licensing agreements include a grant-back clause.

advantage with learning through internal and external processes. We argue that licensing agreements are increasingly more likely to include a grant-back clause, the closer the licensed technology is to the core of the licensor's patent portfolio. On the licensee's side, we conjecture that these agreements are decreasingly likely to contain a grant-back clause, the closer the licensed technology is to the core of the licensee's patent portfolio.

We hypothesize that a licensing agreement will be increasingly likely to include a grant-back clause if the licensed technology is associated with high uncertainty. However, these variables interact in important ways: We would argue that technology licensing agreements involving technologies that are core to the licensor and at the same time are uncertain will further increase the probability of including of a grant back-clause. We would argue also that the smaller likelihood of a grant-back clause in technology licensing agreements involving technologies that are related to the licensee's core knowledge, is reversed in the case that the licensed technology is uncertain.

We test the proposed hypotheses using a sample of 404 licensed technologies extracted from Recombinant Capital's Biotech Alliance Database for the period 1984-2004. We combine the information retrieved for licensing deals with patent data from the NBER project with firm information from the COMPUSTAT database. We employ a hierarchical nested decision model to account for the fact that the inclusion in a licensing contract of a grant-back clause is nested in the decision regarding which technologies to out-license. Accordingly, the empirical model comprises a two-level asymmetric nested tree in which the option of a grant-back clause is available only if the licensor decides to out-license a technology. To implement this technique we use the unique USPTO (United States Patent and Trademark Office) patent number assigned to each technology in the licensing database to estimate the likelihood that a specific technology

will be licensed. Then we estimate the extent to which the licensed technology represents a core technological activity of licensor and licensee and the effect of technological uncertainty, on the likelihood that a grant-back clause will be included in the contract. We find overall empirical support for our theoretical arguments.

THEORETICAL BACKGROUND

The RBV and the competence-based view of the firm highlight that sustained competitive advantage can be achieved through the ownership of valuable resources that are imperfectly mobile and imperfectly imitable (Wernerfelt, 1984; Barney, 1991; Peteraf, 1993). We draw on this view and the extension proposed by Lavie (2006), who relaxes the fundamental assumption in the original RBV, that firms must own or at least fully control the resources that confer competitive advantage. Relaxation of this assumption is central to the extended RBV which claims that firms achieve sustained competitive advantages through collaboration with other firms.

The conventional RBV frame considers only *internal rents*. Internal rents are a combination of Ricardian rents and quasi-rents derived from the focal firm's internal resources (Peteraf, 1993; Lavie, 2006). Lavie (2006) also considers three additional types of rents that are related to the focal firm's external relations. *Appropriated relational rents* refer to the joint benefit that accrues to collaboration partners through the combination, exchange and co-development of unique resources and are the rents considered in the relational view of the firm (Dyer and Singh, 1998). *Inbound spillover rents* are private benefits that are derived by the focal firm exclusively from external resources subject to unintended leakages of knowledge from collaboration partners,

pertaining from both shared and non-shared resources of the collaboration partners.[2] *Outbound spillover rents* refer to the opposite situation where the unintended leakage of the resources of the focal firm produce private benefits for collaborating partners, thereby reducing the focal firm's competitive advantage. In our hypotheses we apply these distinctions among types of rents relating to benefits/rents that can be gained or lost through interaction with collaboration partners. In the present paper, we focus on technological resources. In many industries, technological resources are of central importance for sustained competitive advantage (Silverman, 1999).

To understand the inclusion of grant-back clauses in licensing contracts we combine insights from the RBV with the logic provided by incomplete contract theory in contract economics. Under the assumption of information asymmetry between trading parties, incomplete contract theory studies whether either of the contracting parties has an incentive to act opportunistically, and relatedly, whether either party has an incentive to invest effort in the transaction (Bolton and Dewatripont, 2005). In this context, Choi (2002) is a particularly important contribution which is based on incomplete contract theory and addresses the already mentioned boomerang effect. The boomerang effect implies that granting licensees the right to use the licensors' intellectual property "may enable them to develop new products, which make the licensed technology obsolete and leave the licensor in backwater of technology" (Choi, 2002: 804). Choi (2002) shows that a quantity-dependent royalty payment can serve as a hostage that will help facilitate the transfer of the cutting-edge technology. The inclusion of a royalty rate, however, incurs high costs for the licensee. If too high, then the best technology will not be transferred. Thus a grant-

[2] The two-sided nature of spillovers was acknowledged and used analytically in Myles Shaver and Flyer (2000). The notion of inbound and outbound spillovers corresponds to Cassiman and Veugelers's (2002) concepts of incoming and outgoing spillovers, which are applied for instance, in Alcácer and Chung (2007).

back clause can reduce the costs imposed by a quantity-dependent royalty payment, thereby facilitating trade. However, depending on the type of technology and its importance to the trading parties' technological portfolios—related to their ability to maintain competitive advantage—a grant-back clause will be more or less likely to be included in the licensing contract.

HYPOTHESES

Licensors' core technologies

A given firm possessing technological resources will have a portfolio of core and non-core technologies related to its activities (Granstrand et al., 1997). The firm's core technologies will be underpinned by a set of in-house core competencies (Prahalad and Hamel, 1990).

The licensing literature generally does not consider the licensing out of core technologies, because of the potential loss of competitive advantage (see e.g., Caves et al., 1983). However, under certain conditions firms do license-out their core technologies provided they can do so while also avoiding creating direct competitors (for an overview, see Leone and Laursen, 2011). In these cases, the licensing contract will be more likely to include a grant-back clause for three main reasons. First, the potential boomerang effect will be more severe for the licensor if it involves a core technology and related core competencies, because of the competitive advantage and internal rents they provide. If these advantages are eliminated through the boomerang effect and resulting obsolescence of the core technology, the consequences for the licensor may be dire. There is a strong likelihood that competition in the market will increase and new competitors will emerge. However, a grant-back clause reduces these risks. From the licensee's perspective, even though the inclusion of a grant-back may reduce the potential advantages of investing in the

license, it still assures access to a technology with a high potential, which subsequently may result in a successful commercial exploitation.

Second, assigning more residual rights of control to the principal (the licensor) shifts the incentives for opportunistic and distorting behavior as a result of the lower *ex-post* returns to the agent (the licensee). As a result, the licensee will commit fewer resources to the development of the in-licensed technology since the potential for achieving competitive advantage based on development of the technology will be reduced. Van Dijk (2000: 1433) state that "future exchange clauses obviously weaken (licensee's) incentives to improve current technology." For licensees, the potential competitive advantage deriving from technology improvements is reduced because the advances achieved have to be transferred to the licensor. For the licensor, the risk of being overtaken by the licensee in a core technology is reduced as the result of a grant-back clause which increases the chances of maintaining the internal rents related to the core technology.

Third, the inclusion of a grant-back clause provides an incentive for the licensor to assist the licensee in developing the technology further and forging a collaborative learning-related arrangement based on the license (Leone and Reichstein, 2012). A collaborative arrangement will increase the possibility of outbound spillover rents from the point of view of the licensor. This may be particularly dangerous if the collaboration is related to core technologies and the associated core competencies. However, the inclusion of a grant-back clause means that the potential outbound spillover rents become realized relational rents. In sum, we submit:

> *Hypothesis 1: Technology license agreements, ceteris paribus, are increasingly likely to include a grant-back clause the closer the licensed technology is to the core of the licensor's patent portfolio.*

Licensees' core technologies

There are many reasons why firms choose to in-license technologies. In the standard licensing literature, potential licensees are attracted by the rapid access to technologies that have been developed and proven by their licensors in other competitive arenas (Atuahene-Gima, 1992, 1993). In this literature, licensing-in is seen as a tactical response to a shortfall in internal R&D capabilities (Lowe and Taylor, 1998). However, in-licensing is also considered a learning mechanism allowing combinations of complementary internal and external pieces of knowledge (Lowe and Taylor, 1998; Choi, 2002; Johnson, 2002; Laursen et al., 2010; Leone and Reichstein, 2012). According to Choi (2002: 807): "licensing of a new technology serves as a stepping stone for further developments of the licensed technology."

We hypothesize that a licensing agreement related to a core technology in the licensee's patent portfolio is very unlikely to contain a grant-back clause for two main reasons. The first is the level of absorptive capacity needed to integrate the in-licensed technology (Laursen et al., 2010). Cohen and Levinthal (1990: 128) argue that a firms' absorptive capacity is "largely a function of the level of prior related knowledge." This related prior knowledge allows "the firm to better understand and therefore evaluate the import of intermediate technological advances that provide signals to the eventual merit of a new technological development." (Cohen and Levinthal, 1990: 136). If the licensee's core technology and related core competencies are technologically proximate to the in-licensed technology, it is likely that the licensee firm has identified the appropriate patent and will be able to assimilate and exploit the knowledge contained in the in-licensed technology (for a similar logic applied to R&D-related strategic alliances, see Mowery et al., 1996): The licensee will likely understand the externally acquired technology based on its prior knowledge. However, in the case of an unfamiliar technology, it

will be difficult for the licensee to integrate the licensed technology into its activities. In this case, a grant-back clause will create an incentive for the licensor to help the licensee to integrate and develop this new technology (Leone and Reichstein, 2012). This is unnecessary for a technology that is close to the licensee's core technologies.

The second and closely related reason is that licensing agreements entail the risk of involuntary bidirectional spillovers. They hold the potential for outbound spillover rents seen from the point of view of either party. As already mentioned, grant-back clauses are often included to facilitate technological cooperation, and provide the licensor with an incentive to help the licensee understand, integrate and develop the in-licensed knowledge. The licensor might be encouraged to invest extra time and resources to provide supplementary knowledge if there is some potential for future benefits from grant-backs (Parr and Smith, 2005). However, when the licensed in technology is close to the licensee's core technology (involving a high probability of absorption without direct technological collaboration with the licensor) then the licensee will not be keen to work cooperatively. It will be more interested in avoiding knowledge leaks on core technologies and related core competencies to the licensor (inbound spillover rents to the licensor/outbound spillover rents from the licensee). On this basis, we posit the following hypothesis:

> *Hypothesis 2: Technology license agreements, ceteris paribus, are decreasingly likely to include grant-back clauses the closer the licensed technology is to the core of the licensee's patent portfolio*

Licensors and uncertain technology

Another aspect affecting the structure of contracts is the uncertainty of the licensed technology. According to Ziedonis (2007: 2624) technological uncertainty is related to "the commercial

potential of the patent [...] and is likely to be higher for technologies that are more 'basic' or more 'distant' from commercialization". It is more difficult to forecast the technical performance and feasibility of these types of technologies since they have not been commercialized. In other words, technological uncertainty refers to the uncertain future payoffs from investment in the new technology (Ziedonis, 2007). In line with this definition, our measure of uncertainty is intended to reflect the level of uncertainty related to the future development of the licensed technology.

If the licensor cannot predict the future trajectory of the licensed technology it will be less inclined to license it out. A licensee's attempt to improve on the original technology may totally fail; might result in an incremental improvement to the original technology, or might result in a radical innovation that challenges the licensor's competitive advantage. The licensor cannot judge what might happen but will hedge against the worst possible outcome, which might result in it being overtaken by the licensee. As we pointed out earlier, the inclusion of a grant-back clause provides the licensor with a safeguard by ensuring it access to the results of developments undertaken by the licensee before the latter can exploit them in the market (Schmalbeck, 1975). Hence, the potential utility of a grant-back clause increases with the uncertainty of the technology as such a clause may facilitate technology transfer that would otherwise not have happened due to the licensor's fear of being taken over by the licensee. In the case of uncertainty about the future of a technology, joint learning may contribute more competencies than possessed by either individual firm, and introduce risk sharing, becoming a feasible way to resolve development problems (e.g., Mariti and Smiley, 1983; Sampson, 2007). A grant-back clause provides the licensor with an incentive to collaborate with the licensee over the

technology which may benefit both contracting parties. Based on these considerations, we hypothesize that:

Hypothesis 3: Technology license agreements are, ceteris paribus, increasingly likely to include a grant-back clause with increasing levels of uncertainty.

Licensors' core and uncertain technologies

We have argued that licensing agreements are more likely to include a grant-back clause if they represent a core technology of the licensor, or if the technology is uncertain in relation to its future development. If both conditions hold, this should increase the likelihood of including a grant-back clause even further.

We argue that if the given development of the technology is relatively predictable and "safe", then even if it is a core technology of the licensor, the license may not include a grant-back clause because the risk of a critical boomerang effect will be small. If the technology is uncertain and non-core, the licensor firms might consider a license that does not include a grant-back clause because the damage caused by a boomerang effect—and the consequential reduction in the internal rents—would likely be small in the case of a non-core technology. However, if the technology is core to the licensor and uncertain regarding its future opportunities, the potential damage to the competitive advantage of the licensor firm could be huge. Consequently, we suggest:

Hypothesis 4: Ceteris paribus, the increasing likelihood of a grant-back clause appearing in technology licensing agreements involving technologies that are core to the licensor increases further when the uncertainty of the licensed technology is high.

Licensees, and core and uncertain technologies

We have argued that the inclusion of a grant back-clause will be less likely if the licensed

technology is close to the licensee's core technologies. However, we would argue also that this effect will be reversed if the technology is also uncertain in relation to its application and development. The theory is as described below:

As discussed above, the effect of uncertainty on its own typically leads the licensor to require the inclusion of a grant-back clause to reduce the boomerang effect. However, in the case of uncertain technology, the licensee may require the assistance of the licensor to exploit the technology in its processes even when it is close to its core knowledge. A technology that is not close to commercialization generally involves a relatively high proportion of tacit knowledge. This tacit knowledge is embedded in the licensor and can only be transferred through direct collaboration (Nelson and Winter, 1982; Szulanski, 1996). A grant-back clause secures the sharing of property rights *ex post* (giving rise to appropriated relational rents) and gives the licensor an incentive to assist the licensee in the development of the technology (Leone and Reichstein, 2012). Accordingly, we conjecture:

> *Hypothesis 5: Ceteris paribus, the decreasing likelihood of a grant-back clause appearing in technology licensing agreements involving technologies that are core to the licensee is overturned to an increasing likelihood, when the uncertainty of the licensed technology is high.*

DATA AND METHOD

Data

This study exploits multiple data sources. First, it draws on U.S. pharmaceutical industry technology licensing contracts in Recombinant Capital's Biotech Alliance Database (Recap). The Recap database is used extensively in the licensing literature making this study comparable with and integral to existing work in this area (e.g., Schilling, 2009; Ceccagnoli et al., 2010). It

allows direct access to original contracts, inspection and cross checking of contracts, and the extraction of detailed and precise information on the technology, the involved parties and the contractual specifications. While Recap includes several types of contracts the present study is interested only in technology licensing contracts, and specifically, those involving the transfer of patented inventions listed at the USPTO. This allows the extraction of additional data on the traded technology from the NBER Patent database, which covers all granted USPTO patents.[3] Matching of these datasets in relation to the technology is based on the 7 digit USPTO patent numbers listed in the licensing agreements. It allows us to attach technology related variables to the licensing contracts (e.g. technology age and value).

The licensing agreements also contain the licensor and licensee company names. Matching licensors company names with the patent database identifies sub-contracting deals,[4] which are excluded since sub-contracting generally differs from regular contracting: the licensor's attachment to and insight into the underlying technology is different if it was not the original developer. Sub-contracts may also be subject to contractual conditions dictated by the original out-licensing to the current licensor.

We extracted information on licensors from COMPUSTAT. The two datasets were integrated using company name, address, and industry affiliation. This gives the COMPUSTAT firm identifier (GVKEY) used also in the NBER USPTO database and describes the technological profiles of licensors *ex ante* licensing-out. We are able to extract all patents applied for by the licensor which were eventually granted, and which the licensor could consider potential technologies for licensing-out.

[3] NBER patent data are described in detail in Hall et al. (2001).

[4] We identify cases where the licensor firm is different from the patenting firm.

NBER patent data are matched with the Recap licensees using company name and country affiliation, providing a profile of the technology *ex ante* licensing-in. Use of patent data for this purpose is imperfect. For example, some firms are not listed as assignees on patents, but this does not mean they do not have a technological profile. For these few firms it is impossible to operationalize the key variables of interest. Our results are therefore conditional on firms having patented at least once before entering into a technology-licensing contract. Although this is a second-best solution, the results are comparable to other studies of the markets for technology (see e.g. Ziedonis, 2007; Parrotta and Pozzoli, 2012)

The USPTO patent numbers are used to combine the licensed technologies with the Harvard Patent Network Dataverse. This database contains additional information on the nature of the backward citations in each patent. We use the Dataverse database to retrieve further information on the number of scientific references cited by the patents in our sample. This information is used to calculate the uncertainty related to the licensed technologies.

Dependent Variable

We use the portfolio of patents of identified licensors and the licensed technology to build the dependent variable. We scrutinized the contracts for grant-back clauses, generally to the effect that the licensee must grant any future improvements to the licensed technology back to the licensor. The dependent variable is a three level categorical variable indicating the status of a patent with respect to licensing and the inclusion of a grant-back clause. Some technology is not licensed out; some is licensed out under a contract that does not include a grant-back clause; and some technology is licensed in under a contract that includes a grant-back clause. The three categorical levels therefore are: (1) *non-licensed technology*; (2) *licensed technology without the grant-back clause*; and (3) *licensed technology with the grant-back clause*. The unit of analysis

for the empirical investigation is the level of the technology. This set-up allows us, at least partially, to circumvent any potential self-selection issues that arise from the inclusion of a grant-back clause being conditioned by the decision to license the technology in the first place. Related, due to the self-selection issues, we also need to consider controls for the likelihood of the technology being exchanged in the market.

Independent Variables

The first explanatory variable is whether the license is for the firm's *core technology*. This is measured by the firm's patenting activity prior to the licensing agreement. This measure is operationalized using the *focal index* proposed by Ziedonis (2007) , which captures the degree of overlap of the firm's core technology with the licensed technology. Higher values indicate that the licensed technology is nearer to the licensor's or licensee's core technological activity. The measure is computed as follow:

$$\textit{Licensor/licensee core technology} = \left[\frac{\left(\sum_{t-6}^{t}\sum_{j}\tilde{C}_i\cdot\rho_i\right)_c}{\left(\sum_{t-6}^{t}\sum_{j}\tilde{C}_i\cdot\rho_i\right)}\right],$$

where $\left(\sum_{t-6}^{t}\sum_{j}\tilde{C}_i\cdot\rho_i\right)_c$ represents the citation-weighted sum of firm *i*'s patents applied for within six years of the date of the license agreement *t* and which to the same primary patent class *c* as the licensed technology; and $\left(\sum_{t-6}^{t}\sum_{j}\tilde{C}_i\cdot\rho_i\right)$ is the sum of all citation-weighted patents issued to the firm *j* that were applied for by date *t*. The use of weighted citations allows us to capture the relative importance of each patent in the firm's portfolio (Griliches, 1990). The index is calculated separately and independently for licensors and licensees. It ranges between 0 and 1 where 1 indicates that the technology is a core technology and there is a complete overlap of the primary patent class of the licensed technology and the technologies of the focal firm.

The second explanatory variable refers to *technological uncertainty*. The uncertainty of a technology relates to its technical features and potential development into commercial products or market applicability (Rosenberg, 1996; Huchzermeier and Loch, 2001). Technological uncertainty is calculated as the share of scientific references listed in backward citations on the licensed patent. While "*early-stage*" technologies are founded on basic research (scientific knowledge), technologies that are closer to commercial application include fewer references to basic knowledge and a larger share of references to other patented inventions (Narin et al., 1987; Rosenberg, 1996). This measure of technology uncertainty also takes account of the qualitative aspects of backward citations.

Control Variables

Royalty rate: The inclusion of royalty fees in licensing contracts ensures that the licensor will generate sufficient revenue from the licensing deal to overcome any decrease in profits caused by future competition (Fosfuri, 2006). For this reason, licensing deals involving licensor's core technologies are expected to include higher monetary compensation than contracts dealing with peripheral technologies (Choi, 2002). Also, the inclusion of royalty payments in the remuneration structure of licensing contracts gives the licensor a greater incentive to commit to transferring the knowledge required by the licensee to fully exploit the licensed-in technology. We control for a contractually-specified, fixed royalty rate that the licensee must pay to the licensor.

Technological superiority: The likelihood of a grant-back clause being included in a technology licensing deal may be associated with the licensee's and licensor's relative technological capabilities. Licensors that are technologically superior will have fewer incentives to demand a grant-back clause, given that the recipient firm is unlikely to develop the technology

at a rate or in a direction that would represent a threat to the licensor in either the technology or product markets. Licensors instead will seek to negotiate other conditions favorable to them. The licensor's technological superiority is measured as the difference between the logarithm of licensor and licensee's patent stock accumulated over the eight years prior to the licensing year. Positive values indicate that the licensor is technologically superior; negative values indicate that the licensee is superior.

Patent value: Following the convention in patent studies (Trajtenberg, 1990; Ziedonis, 2007; Lahiri, 2010; Yang et al., 2010), we proxy the economic value of a technology as a time invariant measure of the total number of forward citations received by a patent from its date of publication to 2006.[5]

Technology radicalness: The radicalness of the technology is measured following Rosenkopf and Nerkar (1999). They use the number of different three-digit level IPC classes related to the patents cited by the patent for the focal technology, excluding the class of the focal patent. The fact that the backward citations in a patent refer to different classes (than its own) indicates that the invention builds on several different technological fields (Shane, 2001).

Technology scope: Technology scope is an indication of its applicability which may be a sign of the potential for further development and may increase the licensor's incentive to include a grant-back clause in a licensing contract with another firm. We follow the measure for scope proposed in Lerner (1994), which considers the number of international patent classes that USPTO assigns to a patent as an indication of the breadth of its technology base and intellectual property protection.

[5] That is the latest year available in the NBER patent database.

Technology age: The age of a technology can influence the licensor's decision to commercialize it by licensing it out or exploiting it in-house. Several studies suggest that licensors are less likely to license-out technologies that might undermine their competitive position in the industry (see e.g. Leone and Reichstein, 2012). Firms will therefore be less likely to commercialize more recent inventions, given that these technologies supposedly are at the technological frontier of their inventive activities.

Backward citations: It has been claimed that the total number of backward citations in a patent are a good indicator of the size of the technological space and scope of the intellectual property rights of a given technology (Harhoff and Reitzig, 2004; Reitzig et al., 2010). Technologies with a large number of backward citations may be more likely to be licensed since they may overlap more technological actors and be attractive to more agents on the demand side of the market for technology.

R&D intensity: The firm's relative R&D expenditure may affect its decisions regarding technology licensing. Firms that are R&D intensive are likely to be less dependent on specific technologies, while firms with low levels of in-house R&D are likely to have fewer technological opportunities (Dosi et al., 2006). It is likely also that firms that invest hugely in R&D are pursuing purely technology driven strategies which do not include traditional commercialization, and whose profits lie in exchanges of intellectual property. This may introduce heterogeneity in the decision to enter the markets for technology. R&D intensity is measured as firm *i*'s total amount of R&D investment divided by its sales in year *t*.

Licensor technological specialization: The firm's level of technological specialization is likely to affect the way it operates in the markets for technology: narrower technological scope renders the firm more susceptible to rent dissipation when licensing core technologies. Therefore

we include a measure of technological specialization by calculating a Herfindahl index for the total number of patents in the firm *j*'s patent portfolio accumulated during in the seven years before the license agreement. We operationalize this measure as follows:

$$\textit{Licensor technological specialization}: \quad \sum_{j=1} \left(\frac{N_{ij}}{N_i}\right)^2$$

Firm slack. The availability of slack resources can affect the novelty of innovations (Nohria and Gulati, 1996). Given that firms ability to introduce innovations, characterized by a high degree of novelty may affect a firm's licensing decision, we control for firm *i*'s slack using the ratio current assets/current liabilities in year *t*.

Firm size. We control for firm size using the logarithm of total number of employees in a given year.

Licensor market diversification: We control for the number of different markets in which the licensor operates by counting the total number of different SIC codes reported in the COMPUSTAT database at year *t*. This may spread the risks for the licensor, which may have an influence on inclusion or not of a grant-back clause.

Technological fragmentation. The degree of fragmentation of ownership in the firm's patent portfolio has been shown to affect patenting behavior and the strategic decisions related to exploiting the market to commercialize new technologies (Ziedonis, 2004). We control for fragmentation of ownership rights of firm *j*'s patents produced at year *t* are using the fragmentation index proposed in Ziedonis (2004):

$$\textit{Technological fragmentation} = 1 - \sum_{j=1} \left(\frac{NBCITES_{ij}}{NBCITES_i}\right)^2, \ i \neq j,$$

where *j* refers to the unique entities cited by the patents granted to firm *i* in a given year (NBCITES is the aggregate number of backward citations). [6]

Sales change. Licensors that experience a decrease in their sales may be under pressure to generate short-term revenue by licensing their more valuable technologies (Katz and Shapiro, 1986). Percentage change in licensor's sales between the licensing year *t* and *t-1* is used to control for a licensing decision motivated by financial pressures.

Finally, patenting propensity varies across years and industry segments, resulting in the need to protect an invention differing across and within the firms in our sample. To account for these effects we include dummy variables for biotech and for medical firms (within the pharmaceutical industry) and year of the licensing contract.

Econometric Analysis and Model Choice

With a categorical multinomial dependent variable, the first choice model would be a multinomial logit. However, the grant-back clause cannot be considered independently of the likelihood that a technology is licensed-out. The likelihood of a technology being licensed may have an impact on the inclusion of a grant-back clause, and the grant-back clause may be subject to bias depending on the possibility of its inclusion. Hence, the different outcomes for the dependent variable may not be considered independent irrelevant alternatives (IIA), as assumed by the multinomial logit. We investigate also whether the IIA problem persists only theoretically or is an empirical challenge as well. Using a Brant test, we find strong evidence of a violation of the IIA assumption when applying multinomial logit estimation.

This paper applies a hierarchical nested logit specification to model the likelihood that a grant-back clause will be included in the licensing contract. These specifications split the

[6] In line with how the measure originally was calculated we exclude from the backward citations references to the firm's own patents, to expired patents and to non-patented products.

categorical values into nests representing mutually dependent decisions (Manski and McFadden, 1981). This model therefore is congruent with the decisions regarding the licensing of a technology and inclusion of a grant-back clause being interlinked. This model choice enables joint estimation of the impact of firm and technology characteristics on the licensing decision and inclusion of a grant-back clause. The applied specification is a two level nested logit model with random utility maximization (RUM) and full information maximum-likelihood estimation. This setting allows separation between use of a grant-back clause and the licensing decision, while preserving the correlation between these two outcomes (Ziedonis, 2007).

<INSERT FIGURE 1 ABOUT HERE>

Figure 1 shows that the nest splits the sample across the three levels of the dependent categorical variable creating an asymmetric tree structure. The first nest utilizes all the USPTO patents produced by the licensors in the same year as the licensed technology, assuming that they are all included in the portfolio of technologies that potentially could be licensed out. There were 7012 patents which were not included in the Recap dataset; we assume they were never licensed out, leaving 404 patents which we classify as being licensed out, from a total of 7416 technologies identified.[7]

A potential limitation of this setting is that firms might also license non-patented inventions, which are not included in this empirical setting. However, previous studies (Arora and Ceccagnoli, 2006: 294) show that there is a connection between patenting behavior and licensing activity, suggesting "the presence of a patent is almost essential for licensing". These authors

[7] We excluded 239 technologies produced in the same year as the licensed technologies because they had two or more different assignees, indicating that the property rights for those patents were shared among firms.

also show that less than 10 percent of licensors do not patent.[8] Also, using only patented inventions to compare licensed versus non-licensed technologies ensures analytical consistency. Another potential issue related to our setting is that a certain technology may have been licensed but not reported in the Recap database. However, we have no reason to suspect that, if this were the case, the technologies not reported in the licensing database would be systematically correlated with the likelihood of being licensed under a grant-back clause.

This study uses interaction terms to estimate the determinants of the likelihood of a grant-back clause in a licensing contract. This modeling technique requires some shaping of the data (Drucker and Puri, 2005) so that observations are classified as: (1) *non licensed technology*; (2) *licensed technology without the grant-back clause*; or (3) *licensed technology with the grant-back clause*. This increases the number of observations threefold, transforming the 7416 observations into 22,248 and generating three evenly distributed dummy variables, with 7416 positive outcomes for the three possible outcomes. Because there is no within-case variability in the second nest, following Drucker and Puri (2005), we created pseudo alternative specific outcomes for the explanatory variables by interacting them, in this nest, with the outcome variable (grant-back clause).

RESULTS

Table 1 reports the descriptive statistics for the variables considered in the analysis and their Pearson correlation coefficients. Since some of the variables are calculated and used only for the 404 observations, Table 1 reports the statistics for this number of observations. None of the correlations suggest any multicollinearity problems in the regression analysis. This is confirmed by variance inflation (VIF) analysis. The maximum VIF associated with any of the independent

[8] In the Recap database after dropping the firms for which there was no publicly available information, we had no cases of licensors that did not patent.

variables is 2.78 (mean VIF = 1.40). The statistics are consistent when using the entire dataset for those variables where it is possible.

<INSERT TABLE1 ABOUT HERE>

Table 2 summarizes the results of the regression analysis. Model I reports the results considering only the controls, while models II-V introduce the explanatory variables and their interactions gradually. Table 2 provides support for Hypothesis 1 suggesting technology license agreements are increasingly likely to contain a grant-back clause the closer the licensed technology is to the licensor's core technology, and for Hypothesis 2 suggesting that technology license agreements are decreasingly likely to contain a grant-back clause the closer the licensed technology is to the licensee's core technology. The parameter estimates for licensor's/licensee's core technology are statistically positively/negatively significant in all the models in which they are considered (II-V). The evidence slightly favors Hypothesis 1 compared to Hypothesis 2. However, both hypotheses are supported at a minimum 5 percent level of significance.

<INSERT TABLE2 ABOUT HERE>

Table 2 provides support also for Hypothesis 3 that the more uncertain the licensed technology, the more likely the technology license agreement will include a grant-back clause. The parameter estimates for uncertainty are significantly positive in all the models. In model II provides weak support at a 10 percent level of significance; this significance level is higher in models III, IV and V.

The data do not support Hypothesis 4 regarding the likelihood of a grant-back clause in technology licensing agreements involving technologies that are core to the licensor increasing if the licensed technology is uncertain. None of the interaction parameter estimates between uncertainty and licensor core technology are significant. Accordingly, we find no evidence to

suggest that the parameter estimate of the interaction between the licensor's core technology and technological uncertainty will be greater in absolute terms than the estimate associated with the licensor's core technology. This is confirmed by a Wald test.

We find statistical support for Hypothesis 5 that the decreasingly likelihood of a grant-back clause in technology licensing agreement involving technologies that are core to the licensee becomes an increasing likelihood when the licensed technology is uncertain. The Wald test suggests that the parameter associated with the interaction between licensee's core technology and uncertainty is significantly greater than the absolute value of the parameter estimate of licensee's core technology. Model V shows that (1.8+4.7=0) is statistically greater than zero.

Among the controls we find that contracts specifying higher royalty rates are more likely to have grant-back clauses and that contracts between parties where the licensor is technological superior tend not to contain grant-back clauses. The evidence suggests that higher value; more radical technologies; and older technologies are more likely to be licensed. We find evidence also that technologies that are broader in scope are typically not licensed. Among firm characteristics, the empirical results suggest that R&D intensive and more technologically specialized licensors tend to engage in licensing activity. In line with previous studies, we find that larger firms and firms characterized by a higher level of technological fragmentation tend not to engage in technology licensing.

Sensitivity Analysis

We conducted several additional analyses to ensure that our results were not a by-product of our empirical choices. First, we considered the variables for which we chose a particular time window and varied the time dimensions (plus/minus 2 years). We found no evidence that our choice had any impact on the overall results of the model.

We considered the fact that some firms appear more than once in the dataset since they had engaged in licensing-out more than one technology. This means that some observations are not independent of each other, which potentially could introduce some bias in our estimators since this is standard practice in some firms and not a by-product of the general tendency in a random sample of observations. To consider this potential source of bias, we ran a nested logit model with the bootstrap specification on the data. The results were similar to those presented in the main analysis. We therefore consider that this issue is of limited concern.

Since the statistical significance of the uncertainty variable increases with the introduction of the interaction terms, we investigated the degree to which the statistical evidence and support for the hypothesis might be attributable to a potential multicollinearity problem. We ran split regressions based on mean values of the uncertainty variable. This provided evidence supporting the reported results showing that the analysis is generally robust against this potential source of bias.

CONCLUSION AND DISCUSSION

We began this paper by discussing the so-called "boomerang effect" proposed by the theoretical technological licensing literature. Against this backdrop, we examined the effect of the match between licensed technologies, and licensors', licensees' and technology characteristics in determining the probability of a grant-back clause being included in the licensing agreement. By combining insights from the RBV of the firm with contract economics, we proposed theoretical arguments related to contracting firms' requirements to balance the need to protect their technological resources with the need to learn through internal and external processes. We theorized and found empirical support for the idea that licensing agreements are increasingly likely to contain a grant-back clause if the licensed technology is close to the licensor's core

technologies. We found also that licensing agreements are decreasingly likely to contain a grant-back clause if the licensed technology is close to the licensee's core technologies. We found support for the idea that licensing agreements are increasingly likely to contain a grant-back clause when the licensed technology is uncertain/unproven.

We identified how these variables interact: We argued that technology licensing agreements involving technologies that are core to the licensor and at the same time are uncertain, should further increase the probability of a grant back-clause being included. However, we did not find support for this idea: The two variables have a separate influence, but we observed no complementarity to make their combined effect even stronger. Finally, we explored whether the decreasing likelihood of a grant-back clause in technology licensing agreements involving technologies that are core to the licensee is overturned if the licensed technology is uncertain. We found empirical support for this argument.

Our work provides two main contributions. First, we extend the theoretical understanding of the functioning of the markets for technology as expressed in the strategic management literature (e.g. Fosfuri, 2006; Ceccagnoli and Jiang, 2012), by identifying the beneficiaries of the rents from potential licensing relationships, which often preclude potentially mutually beneficial deals. We also show and how these undesirable potential rents can be prevented by an appropriate contract design. More broadly, we provided further evidence that the design of contracts matters for firm behavior (Poppo and Zenger, 2002; Li et al., 2010). Second and related, we extend the resource-based view by highlighting the conditions under which competitive advantage can be achieved through licensing agreements—and when it cannot. Although we did not directly observe firm-performance in this paper, the actions realized by the firms are revealing.

The findings in this study have implications for managerial practice. They should act to guide managers' decision making about how to manage and design licensing agreements. The licensing literature stresses the importance of contract design to avoid *ex-post* problems such as the boomerang effect. In this context, this paper has implications for firms seeking to achieve strategic advantage from entering into a licensing deal. From the licensor's point of view, if the firm decides to out-license a core technology in order to generate licensing revenue and to have a technology further developed by a licensee, it is more beneficial to find a partner with a small technological overlap with the technology to be out-licensed. Given that the grant-back clause reduces the licensee's incentive to invest in the technology, striking a deal with a dissimilar company could increase the licensor's advantage. On the licensee's side, our findings suggest that in the situation that the licensee needs support from the licensor to continue development of the technology, a grant back clause may be "a price worth paying".

This study also has some limitations. First, firms may choose not to disclose certain licensing deals for secrecy and strategic reasons. If this is the case then the representativeness of our database might be affected by selection issues. However, we have no reason to expect that if firms choose not to report certain deals, those unreported observations are systematically correlated with the dependent variable. Second, the use of patents to calculate how core the licensed technology is for the contracting parties has some limitations. Firms may rely on other appropriability mechanisms than patents to protect their most valuable technologies, and these technologies would thus not be captured by our core technology measure. Despite this limitation regarding the use of patents, we believe that the choice of the pharmaceutical industry as the empirical context for this paper to a large degree alleviates these concerns. In this paper we do not examine how participation in the licensing market interacts with other types of knowledge

acquisition (for instance, in the form of R&D collaboration). This could be an interesting direction for future research and might produce insights that would provide important guidance for managers involved in decisions about how to manage and design licensing agreements.

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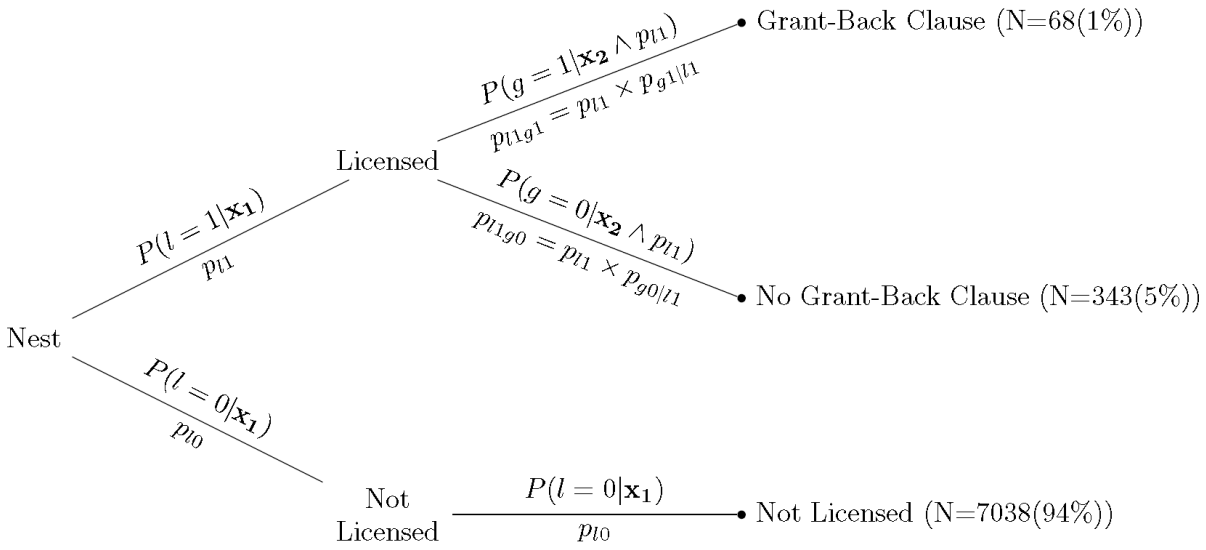

Figure 1: The Hierarchical Nested Tree Structure

Table 1: Descriptive Statistics and Correlation Coefficients (N=404)

Variable	Mean	S.D.	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
[1] Licensor core technology	0.50	0.34	1.00									
[2] Licensee core technology	0.09	0.21	0.04	1.00								
[3] Technological uncertainty	0.61	0.36	-0.02	0.15	1.00							
[4] Royalty rate	6.33	8.38	-0.04	-0.00	0.08	1.00						
[5] Technological superiority	-270.49	1178.68	-0.26	0.05	-0.11	0.05	1.00					
[6] Patent value	41.27	113.86	0.14	0.22	0.08	0.06	0.02	1.00				
[7] Technology radicalness	2.45	2.80	0.02	-0.05	-0.13	0.03	-0.23	-0.01	1.00			
[8] Technology scope	2.42	1.55	0.16	0.12	0.14	0.02	-0.06	0.25	-0.10	1.00		
[9] Technology age	5.00	3.46	-0.13	-0.16	0.04	-0.08	0.22	0.05	0.05	-0.09	1.00	
[10] Backward citations	45.45	56.57	0.09	0.02	0.39	-0.02	-0.20	-0.03	0.40	0.06	0.05	1.00
[11] R&D intensity	110.59	134.07	0.05	0.12	0.15	-0.03	-0.14	-0.11	-0.03	-0.04	-0.25	0.07
[12] Licensor technological specialization	0.40	0.20	0.54	-0.06	-0.06	-0.08	-0.39	0.00	0.13	0.13	-0.24	0.10
[13] Firm slack	6812.16	36855.49	0.05	-0.03	0.06	-0.05	-0.00	-0.01	0.01	0.03	-0.09	0.14
[14] Firm size	5.94	2.48	-0.38	-0.03	-0.09	0.04	0.54	-0.02	-0.17	-0.03	0.27	-0.27
[15] Licensor market diversification	3.06	3.85	-0.16	-0.05	-0.03	0.02	0.28	-0.05	0.13	-0.07	0.42	0.25
[16] Technological fragmentation	0.13	0.27	0.19	-0.11	0.05	-0.13	-0.57	-0.07	0.27	0.04	0.02	0.17
[17] Sales change	3.14	18.12	0.01	0.03	-0.03	0.03	-0.00	-0.03	0.02	0.04	-0.03	-0.01

Variable	Mean	S.D.	[11]	[12]	[13]	[14]	[15]	[16]	[17]
[11] R&D Intensity	110.59	134.07	1.00						
[12] Licensor technological specialization	0.40	0.20	0.12	1.00					
[13] Firm slack	6812.16	36855.49	-0.04	0.10	1.00				
[14] Firm size	5.94	2.48	-0.34	-0.41	-0.19	1.00			
[15] Licensor market diversification	3.06	3.85	0.01	-0.21	-0.02	0.28	1.00		
[16] Technological fragmentation	0.13	0.27	-0.13	0.35	-0.05	-0.17	-0.11	1.00	
[17] Sales change	3.14	18.12	0.06	0.00	-0.01	-0.12	-0.07	-0.03	1.00

Table2: Nested Logit Results for Grant-back Clause and Licensing Decisions

Variables	Model I	Model II	Model III	Model IV	Model V
Grant-back Clause equation					
Licensor core technology		1.407**	1.619**	1.364**	1.665**
		(0.469)	(0.504)	(0.497)	(0.578)
Licensee core technology		-0.796*	-0.764*	-1.653**	-1.807**
		(0.349)	(0.365)	(0.545)	(0.614)
Technological uncertainty		0.440+	0.594*	0.582*	0.799**
		(0.230)	(0.260)	(0.257)	(0.300)
Licensor core technology × Technological uncertainty			-1.186		-1.445
			(0.809)		(0.920)
Licensee core technology × Technological uncertainty				3.887*	4.703*
				(1.689)	(2.035)
Royalty rate	0.057*	0.059***	0.064***	0.056**	0.061***
	(0.025)	(0.017)	(0.017)	(0.017)	(0.017)
Technological superiority	-0.064+	-0.085*	-0.098*	-0.098*	-0.122*
	(0.038)	(0.039)	(0.043)	(0.046)	(0.057)
Technology Licensing Equation					
Technology Characteristics					
Patent value	0.004***	0.003***	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Technology radicalness	0.051*	0.064**	0.065**	0.066**	0.068**
	(0.023)	(0.023)	(0.023)	(0.023)	(0.024)
Technology scope	-0.074+	-0.090*	-0.092*	-0.091*	-0.093*
	(0.040)	(0.041)	(0.041)	(0.041)	(0.041)
Technology age	0.134***	0.128***	0.133***	0.128***	0.134***
	(0.024)	(0.023)	(0.024)	(0.023)	(0.024)
Backward citations	0.000	-0.000	-0.000	-0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Firm Characteristics					
Licensor technological specialization	3.054***	2.530***	2.417***	2.506***	2.338***
	(0.435)	(0.487)	(0.499)	(0.504)	(0.542)
Licensor market diversification	-0.014	-0.012	-0.013	-0.011	-0.011
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Firm size	-0.271***	-0.253***	-0.246***	-0.255***	-0.247***
	(0.029)	(0.030)	(0.030)	(0.030)	(0.031)
Firm slack	0.000+	0.000+	0.000+	0.000+	0.000+
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R&D intensity	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Technological fragmentation	-0.665*	-0.690*	-0.688*	-0.700**	-0.709**
	(0.269)	(0.270)	(0.271)	(0.272)	(0.275)
Sales change	0.004	0.005	0.005	0.005	0.005
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Industry Dummy	YES	YES	YES	YES	YES
Year Dummy	YES	YES	YES	YES	YES
N	22.248	22.248	22.248	22.248	22.248
χ^2	1.751.580	1.410.007	1.278.317	1.341.717	1.138.140
Log Likelihood	-1.518.378	-1.497.569	-1.496.215	-1.493.455	-1.491.737

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