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Evading the Boomerang Effect: Using the Grant-Back Clause to Further Generative Appropriability from Technology Licensing Deals

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Abstract. Technology licensing agreements potentially can create future appropriability problems. Drawing on the appropriability literature, we argue that the inclusion of a grant-back clause in technology licensing agreements is an attempt to balance the gains from and protection of the focal firms' technologies. We hypothesize that the closer the licensed technology is to the licensor's core patented technologies, the more likely the licensing agreement will include a grant-back clause, while the closer the licensed technology is to the licensee's core patent portfolio, the less likely the agreement will include a grant-back clause. We hypothesize also that technological uncertainty is a positive moderator in the decision to include a grant-back clause, if the licensed technology is close to either the licensee's or the licensor's core technologies. We employ a hierarchical nested decision model to test the hypotheses on a sample of 397 licensed technologies. This method allows us to model the choice to include a grant-back clause as nested in the decision about which technologies to license out. We find broad support for our theoretical arguments.

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Keywords: grant-back clause • technology licensing • core technology • appropriability

Introduction

Although there may be potentially large mutual gains from technology transfer and joint technology development between firms, the many appropriability problems related to such activities can act as a deterrent (Agrawal et al. 2015, Arora 1995, Arrow 1962). Thus, technology-related agreements are not a priority for many high-tech firms (Arora and Gambardella 2010). However, from the strategy literature on contract design (see e.g., Argyres et al. 2007, Mayer and Argyres 2004, Ryall and Sampson 2009), we know that firms learn to contract with each other based on prior experience, and that control provisions force the contracting parties to dedicate time and effort to fulfilling their responsibilities rather than to minimizing effort and reneging on the contract arrangements (Malhotra and Lumineau 2011). Well-designed contracts that include clauses that align the actions of the involved parties can reduce the appropriability problems inherent in technology agreements.

Nevertheless, although our understanding of contract design in relation to appropriability in technology-related agreements has advanced significantly, most studies (see e.g., Cebrián 2009, Duplat and Lumineau 2016, Oxley 1997, Oxley and Sampson 2004, Somaya et al. 2011) focus on what Ahuja et al. (2013, p. 248) describe as "primary appropriability," i.e., firms' "effectiveness in exploiting a *given* invention by translating it into a product or licensable solution for users" (emphasis added). Few works investigate appropriation in relation to future inventions spawned by a firm's technologies (Alexy et al. 2013, Allen 1983, Harhoff et al. 2003, Yang et al. 2010) covered by previous technology-related agreements. This type of appropriability can be described as "generative appropriability" or the "firm's effectiveness in capturing the greatest share of *future* inventions spawned by its existing inventions" (Ahuja et al. 2013, p. 248; emphasis added). In the present paper we focus on generative appropriability in the context of technology licensing agreements, which are an important channel for knowledge exchange (e.g., Ceccagnoli and Jiang 2013, Fosfuri 2006, Hill 1992, Mulotte 2014, Ruckman and McCarthy 2016, Schilling and Steensma 2002). Anand and Khanna (2000, p. 103) 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." Given that the direction of developments and the application of technologies in the product market are fundamentally uncertain (Choi 2002, Dosi 1988), in the context of licensing, a central appropriability problem is the possibility that the licensee will develop the focal technology further, and eventually, will overtake the licensor—a phenomenon that has been described as the "the boomerang effect" (Choi 2002, Van Dijk 2000).

In cases where the licensor's value creation from the invention could (potentially) be damaged due to weak appropriability, a control provision in the form of a grant-back clause in the licensing contract is essential to facilitate knowledge transfer, which otherwise would not take place (Choi 2002). A 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 rights" (Schmalbeck 1975, p. 733). A grant-back clause can prove very important for the licensor because it protects against licensees building future inventions based on the in-licensed technology, i.e., it protects the licensor's generative appropriability.

We examine how the importance of the traded technology to the trading parties' technology portfolios influences the inclusion of a grant-back clause, and how these relationships are contingent on the level of technological uncertainty in the traded technology. The economics (Choi 2002, Van Dijk 2000) and strategic management (Leone and Reichstein 2012) literatures include important contributions related specifically to technology licensing, which demonstrate how the inclusion of a grant-back clause affects the behavior of the exchanging partners. However, most work focuses exclusively on the licensor and generally does not identify under what circumstances this type of clause is included in licensing contracts. A deeper understanding is needed of this type of contractual detail, which is crucial for interorganizational arrangements that allow licensor and licensee to guard against potential threats to their future ability to produce inventions and future technology-based rents while not reducing firms' mutual interests in further investment in the traded asset.

Taking the more recent literature on generative appropriability (Ahuja et al. 2013) as our theoretical point of departure, we examine the contingencies that could leave firms particularly vulnerable to a skillful licensing partner's development of future inventions based on the licensing firm's inventions. The combination of these contingencies, the heterogeneity among licensees and licensors, and the level of uncertainty associated with the technology might explain the inclusion of a grant-back clause in a technology licensing agreement. To our knowledge, this attempt to systematically explain this phenomenon is unique. Crucial to our argument is the notion that the contracting firms' core technological areas are more central to their ability to create value compared to other technological areas. We suggest that the combination of (generative) appropriability *protection* and *incentive effects* results in licensing agreements being increasingly likely to include a grant-back clause, the closer the licensed technology is to the licensor's core patents. On the licensee's side, this same combination of effects results in licensing agreements being increasingly less likely to include a grant-back clause the closer the licensed technology is to the licensee's core patents. In addition, since technological uncertainty is central to the boomerang effect and the grant-back clause, we propose that technological uncertainty moderates the relationships described above. That is, technological uncertainty increases the positive effect of the focal technology's proximity to the licensor's core technologies and decreases the negative effect of the focal technology's proximity to the licensee's core technologies.

We test our hypotheses using a sample of 397 licensed technologies over the period 1984–2004, extracted from Recap, the Recombinant Capital Biotech Alliance Database. We merge information retrieved on licensing deals with patent data from the National Bureau of Economic Research (NBER) patent project and firm information from Compustat. This allows us to focus on deals where the licensor is a public firm. We employ a hierarchical nested decision model to account for the inclusion in a licensing contract of a grant-back clause, nested in the decision about which technologies to out-license. Accordingly, the empirical model comprises a two-level asymmetric nested tree in which the grant-back clause option is available only if the licensor decides to out-license the technology. To implement the technique, we use the unique United States Patent and Trademark Office (USPTO) patent number assigned to each technology in the licensing database to estimate the likelihood that a specific technology will be licensed. Overall, we find support for our hypotheses.

Theoretical Background

We depart from the idea that the determinants of generative appropriability comprise two components including (Ahuja et al. 2013, p. 251) the following: (a) a cumulative invention component, defined as the firm's effectiveness in creating a new invention that builds on its existing inventions, and (b) a preclusive component defined as the firm's effectiveness in preventing others from basing their inventions on its own inventions. We discuss these two aspects and how they relate to our setup.

In relation to cumulative invention, although we do not directly consider firms' effectiveness at creating new inventions, we focus on the involved parties' core technologies. Consistent with the innovation literature (see for instance, Patel and Pavitt 1997, Song et al. 2003) we consider the types of technologies in which the firm has accumulated substantial technological experience to have become the core technologies of the firm. A given firm will have a portfolio of core and noncore technologies related to its activities. Our paper builds on the notion that the focal firm's core technologies are more important than other technologies for its generative appropriability, and thus the firm's sustainable long run value creation ability. We assume also that firms' appropriability is more important if it is related to future appropriation of returns from a core technology due to the level and importance of the technology (ceteris paribus) compared to technologies in which the firm has less experience.[1]

Core technologies are important in the context of appropriability in particular because firms' technological specialization profiles across domains are often path dependent (Cantwell and Fai 1999, Patel and Pavitt 1997). This suggests that the firm's production of new knowledge is built on what it has learned in the past, in part because previous knowledge constrains current search for solutions and in part because knowledge raises questions that cause new searches (Breschi et al. 2003, Nelson and Winter 1982, Rosenberg 1976). Ahuja et al. (2013, p. 263) note that the extent of a firm's prior experience in an inventive knowledge domain strongly affects the firm's subsequent invention success in that same domain. That knowledge is cumulative and path dependent implies that the firm's generative appropriability is particularly critical if it is related to the firm's core technologies, precisely because these technologies are very likely to form the basis for its future inventions. In other words, from the firm's point of view, the cumulative invention component of generative appropriability is likely to be based strongly on the firm's core technologies.

We posit that the grant-back clause can be seen as a type of preclusive condition driving appropriability. In line with the innovation literature, we assume that most technology has an important tacit component which makes it only partially codifiable (see, for instance, Pavitt 1988), and also that innovation "is inherently uncertain, given the impossibility of predicting accurately the costs and performance of a new artifact, and the reaction of users to it" (Pavitt 2005, p. 88). These technology and innovation characteristics make it impossible to specify a complete contract to cover efficient and precisely defined knowledge transfer. The inability to specify a complete licensing contract introduces the possibility that the licensor's primary appropriability, and the preclusive component of its generative appropriability, might be eroded by a licensee's follow-on invention (Choi 2002). In this context, a grant-back protects the licensor's core technologies directly but may erode the cumulative invention component of generative appropriability linked to the licensee's core technologies. We describe these effects as (generative) *appropriability protection effects* arising from the inclusion or noninclusion of a grant-back clause.

If it is impossible (or too costly) to specify a complete contract that covers each of the trading partner's rights related to a particular asset, it might be optimal for the licensee to purchase those asset rights not defined explicitly in the contract (Aghion and Tirole 1994, Grossman and Hart 1986). The ownership is endowed by the purchase of residual control rights and creates an incentive to invest in the asset. Thus, the grant-back clause shifts the residual rights of control over a future asset (improvements made to the licensed technology) to the licensor from the licensee, which in turn affects the incentives of both parties to invest in the asset in the future. We argue that these effects are particularly strong if the focal in-licensed technology is essential to the licensor or licensee. The shift in ownership gives rise to (generative) *appropriability incentive effects* from the inclusion in a technology licensing contract of a grant-back clause. The combined effects of appropriability *protection* and *incentive* provided by a grant-back clause, in conjunction with the proximity of a given licensed technology to the core expertise of the licensor or licensee, will determine the inclusion or not of a grant-back clause.

Hypotheses

Licensors' Core Technologies

The licensing literature generally does not consider licensing of core technologies because of the potential for reduced primary appropriability (see e.g., Caves et al. 1983). However, firms will license out a core technology if this can be achieved without creating direct competition (for an overview, see Leone and Laursen 2011). In such cases, the licensing contract is more likely to include a grant-back clause for two main reasons. First, a grant-back clause reduces the licensor's risks by inducing an appropriability protection effect. This allows the firm to benefit from primary (flowing from existing inventions) and generative appropriability related to its own inventions, even if future inventions are generated by the licensee. This is similar to the mechanism described in the literature on selective revealing (Alexy et al. 2013, Harhoff et al. 2003) and knowledge spillover reabsorption (Alnuaimi and George 2016, Yang et al. 2010), where the main motive for revealing is to encourage other organizations to invest in research and development (R&D) to appropriate generative returns at a later stage. This potential boomerang effect will be more severe for the licensor if a core technology is involved, since this represents a central part of the focal firm's technological experience. If the implied ability to produce value is lost through the boomerang effect, the consequences for the licensor of eventual obsolescence of the core technology, combined with the lost ability to generate new inventions based on the previous one, can be severe. Market competition increases, new competitors emerge, and the possibility for the firm to build on its own inventions is reduced. From the licensee's perspective, although the inclusion of a grant-back clause may reduce the potential benefits from the investment, a license still ensures access to a promising technology. The potential gain from the technology could represent a firm-specific value for the licensee that exceeds the potential loss incurred by the inclusion of a grant-back clause.

Second, assigning greater residual rights of control to the licensor can induce an appropriability incentive effect by shifting the incentives for opportunistic and distorting behavior based on lower ex post returns to the licensee. As a result, the licensee will commit fewer resources to the development of the in-licensed technology because the potential for achieving generative appropriability will be reduced. Van Dijk (2000, p. 1433) states that "Future exchange clauses obviously weaken [the licensee's] incentives to improve current technology." In sum, for licensees, the potential rents derived from technology improvements are reduced because any 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 by the inclusion of a grant-back clause, since this increases the chances of maintaining the primary appropriability advantages related to the core technology and obtaining stronger generative appropriability. In contrast, the licensor will have less interest in reducing the licensee's incentive to invest in noncore technologies, since these technologies have less potential to damage the licensor firm's primary and generative appropriability. We propose the following:

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 rapid access to technologies that have been developed and proven in other competing arenas (Atuahene-Gima 1992, 1993). In this literature, in-licensing is seen as a tactical response to a shortfall in internal R&D capabilities (Lowe and Taylor 1998). However, in-licensing is considered also to be a mechanism that enables combinations of complementary internal and external knowledge (Choi 2002, Johnson 2002, Laursen et al. 2010, Leone and Reichstein 2012, Lowe and Taylor 1998). According to Choi (2002, p. 807), "licensing of a new technology serves as a stepping stone for further developments of the licensed technology."

If the licensed technology is closely related to the licensee's core patents, there are two reasons why the licensing agreement is less likely to contain a grant-back clause. The first refers to an appropriability protection effect. Given that the firm's core activities and technology portfolio underpin its ability to earn rents, potential licensees will be reluctant to engage in licensing deals if the contract dictates the sharing of the property rights on future inventions, and especially if the technology is close to the licensee's own core strengths. Given strong path-dependence in firm-level technological developments (see, Helfat 1994, Patel and Pavitt 1997), it is most likely that the licensee also will depend on that technology (or a closely related one) for its generative appropriability. In this context, the preclusive element in the licensee's generative appropriability could be compromised if some of the property rights to the core technology were shared with the licensor through a grant-back clause. This might allow the licensor to become a future competitor. In this case, the licensee would likely abandon the deal or require the grant-back clause to be excluded. In contrast, if the in-licensed technology is mostly unrelated to the licensee's core technologies, the licensee will be less concerned about these potential problems and the inclusion of a grant-back clause in the licensing contract.

The second reason is related to the appropriability incentive effect and the degree of absorptive capacity needed to integrate the in-licensed technology (Laursen et al. 2010). Cohen and Levinthal (1990, p. 128) argue that the firm's 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, p. 136). If the licensee's core technologies are close to the in-licensed technology, it is likely that the licensee 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). Based on its prior knowledge, the licensee will be able to understand and use the externally acquired technology. However, in the case of an unfamiliar in-licensed technology, its integration into the licensee's activities and appropriation of the returns from integration will be difficult. In this case, a grant-back clause will create an incentive for the licensor to help the licensee to integrate and develop the new technology (Aghion and Tirole 1994, Leone and Reichstein 2012). In the case of a proximate technology this cooperation will be redundant. We posit the following:

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

The Moderating Effect of Uncertain Technology

An important aspect affecting contract structure is the licensed technology's level of uncertainty. According to Ziedonis (2007, p. 1624), 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 (Fleming and Sorenson 2004). In line with this definition, our concept of technological uncertainty is intended to reflect the level of uncertainty related to future developments of the licensed technology and the consequent uncertain future application of the resulting invention. Here we posit that the effect of technological uncertainty on the inclusion of the grant-back clause is ambiguous, because the effect will be contingent on the closeness of the traded technology to the licensor's and licensee's core expertise.

In this respect, we argue that even in the case of a core technology if the licensee's potential developments are considered predictable and "safe," then a grant-back clause is likely to be considered unnecessary because of the much reduced risk of a boomerang effect. Similarly, a grant-back clause is likely to be considered unnecessary if the technology is uncertain and noncore, since the potential damage to the licensor from a boomerang effect is likely to be small. However, if the technology is related to the licensor's central area of expertise (a core technology), and future opportunities are uncertain, then there is potential for major damage to the licensor's generative appropriability. In this case, the appropriability protection effects and the incentive effects conveyed by the inclusion of a grant-back clause in the case of licensing out a core technology will be further enhanced by the additional appropriability protection effect provided by the grant-back clause in the case of an uncertain technology. We hypothesize the following:

Hypothesis 3. *Ceteris paribus, the positive relationship between the likelihood of a grant-back clause being included in a technology licensing agreement, and the closeness of the licensed technology to the core of the licensor's patent portfolio, increases with the level of uncertainty associated to the technology.*

We have argued that the inclusion of a grant-back clause is less likely if the licensed technology is close to the licensee's core technologies. However, in the case of both technological uncertainty and a technology that is close to the licensee's core technologies, we argue that the effect will weaken with an increase in technological uncertainty. The appropriability protection and incentive effects that make the grant-back clause undesirable for the licensee in the case of a technology that is core to the licensee, is counterbalanced by the appropriability protection effect the grant-back clause confers on the licensor in these circumstances. In the case of an uncertain technology, predicting the eventual importance of the technology for the licensor's generative appropriability, and predicting where future technology-based competition might emerge, will be even more difficult. In this case licensors are likely to hesitate before licensing out a technology to a licensee with potentially strong ability to absorb and further develop the technology, based on experience with similar technology (Cohen and Levinthal 1990, Mowery et al. 1996). Again, in this case, the licensee firm potentially could achieve generative appropriability based on the in-licensed technology, regardless of its importance to the licensor. Future competition could emerge from improvements to the out-licensed technology given its uncertain direction and application. This potential competition might lead to fewer licensing deals because the inclusion of a grant-back clause would not be in the interests of the licensee (Hypothesis 2). However, if a deal potentially creates high firm-specific value for the licensee, then the deal will likely be concluded although the licensor will be more likely to insist on the inclusion of a grant-back clause in the contract. Uncertain and potentially path-breaking technologies ultimately might be very valuable to the licensee, especially in the case of firms with high absorptive capacity (Ziedonis 2007), i.e., licensees whose core technologies are close to the in-licensed technology. In these circumstances, the licensee will be more likely to accept an otherwise undesirable grant-back clause. Accordingly, we conjecture the following:

Hypothesis 4. *Ceteris paribus, the negative relationship between the likelihood of a grant-back clause being included in a technology licensing agreement, and the closeness of the licensed technology to the core of the licensee's patent portfolio, reduces with the level of uncertainty associated to the technology.*

Data and Method

Data

The study exploits multiple data sources. First, it uses information on U.S. pharmaceutical industry technology licensing contracts drawn from the Recap database. Recap data are used extensively in the licensing literature making this study comparable and integral to other work in this area (e.g., Ceccagnoli et al. 2010, 2014; Hess and Rothaermel 2011; Schilling 2009). These data provide information on original deals, inspection, and cross checking of contracts, and detailed and precise information on the technology, the contracting parties, and the contractual specifications. Recap includes several types of contractual arrangements (e.g., research alliances, joint ventures). The present study considers only technology licensing contracts and specifically those involving the transfer of inventions registered with the USPTO. Technology licenses that involve universities are excluded. University incentive structures differ substantially from businesses, and these licenses may have different underlying determinants. Contract renewals also are excluded, since they often involve only minor revisions to existing contracts. Their inclusion would result in double-counting of specific agreements and could create econometric complications to little or no benefit. Subcontracts are also excluded, since given that the licensor is not the original developer of the technology being transferred, subcontracting generally differs from regular contracting. Finally, we exclude contracts that for confidentiality reasons do not disclose the transferred technology. Information on the technology is required to calculate the key variables. We investigated the degree to which these omitted contracts are more or less inclined to include a grant-back clause and found no particular bias in either direction. Therefore, it is unlikely these exclusion criteria affect the study. Based on these restrictions, we obtained an initial sample of 858 licensed technologies.

Company name, address, and industry affiliation extracted from Recap were used to identify those licensing contracts where the licensor was a public firm listed on Compustat. Restricting the analysis to public firms ensures consistent financial information over different time periods, and restricting the study to firms listed on Compustat reduces the chances of missing (unreported) licensing activities. Recap is compiled based on press releases, Securities and Exchange Commission contracts, analysts' reports, clinical trials, and requests under the Freedom of Information Act, which provides extensive coverage of the activities of large pharmaceutical firms. Compustat listed firms are significantly more likely than small biotech companies to reveal their licensing activities; thus, our focus reduces concern over unreported contracts. The financial information extracted from Compustat was used to compute some of the explanatory variables for licensor characteristics. We excluded 369 technologies licensed-out by a licensor but not listed on Compustat. This left a sample of 489 technologies.[2]

Licensors and licensees were identified using USPTO data. This information allows us to extract patents granted to firms and is used to compute licensors' and licensees' technological profiles before the licensing event. We used data on patent applications five years prior to a licensing contract. Not all firms use patenting as a means of appropriation, which means some firms' technological profiles are unobserved and not included in our analysis. However, since patenting is often a necessary condition for technology licensing, our analysis captures the majority of firms that consider licensing a potential tactical or strategic activity. Previous studies show a connection between patenting behavior and licensing activity, suggesting that "the presence of a patent is almost essential for licensing" (Arora and Ceccagnoli 2006, p. 294). Arora and Ceccagnoli show that less than 10% of licensors do not patent. In addition, using only patented inventions to compare licensed versus nonlicensed technologies ensures analytical consistency. We lost 64 observations since not all licensees (51) and licensors (13) had submitted a patent application during the five years prior to the licensing activity. This reduced the number of technologies available for scrutiny to 425. However, the results are comparable to other studies of the markets for technology (see e.g., Parrotta and Pozzoli 2012, Ziedonis 2007).

Finally, the seven-digit USPTO patent numbers were used to connect individual licensed technologies with the corresponding patent listed in the Harvard Patent Network Dataverse, which includes all USPTO patents granted between 1975 and 2010. This database contains important information on the nature of the backward citations in each patent, the date of public disclosure by the patentee of the licensed technology, and the technology class to which the USPTO assigned the patent. We use Dataverse to calculate uncertainty, age, radicalness, and scope of the licensed technologies. Linking these four databases produced a final sample of 397 *unique* technologies (patents) licensed out by 81 different licensors, and licensed in by 117 different licensees. Only 17 of the contracts have the same licensee-licensor combinations. The 397 technologies refer to 253 licensing contracts.

The combination of multiple data sources allows empirical testing of the effect of firm and technology specific characteristics on contracting behavior. This empirical setting avoids potential bias inherent in using the same data source to compute the dependent and the independent variables. In our case, the dependent variable is based on licensing data (Recap), and the key independent variables are based on patent data. The control variables include variables extracted *grant-back clause* from licensing deal data (Recap), U.S. patent data, and from Compustat.

Dependent Variable

The dependent variable is a dummy for whether or not the contract attached to the transfer of a technology includes a *grant-back clause*. We scrutinized the contracts for indications of a grant-back clause. Some contracts refer explicitly to a grant-back clause; others indicate that the licensor has the rights to any improvements to the licensed technology by the licensee. We interpret both descriptions as expressing contractual agreement to a grant-back clause. The dependent variable takes the value 0 for a licensed technology without the grant-back clause, and 1 for a licensed technology with the grant-back clause.

Independent Variables

Core Technology. This variable is measured as the firm's patenting activity prior to the licensing agreement operationalized as the *focal index* proposed by Ziedonis (2007), which captures the degree of correspondence between the firm's core technologies and the licensed technology. Higher values indicate closer proximity of the licensed technology to the licensor's or licensee's core patent portfolio. The measure is computed as follows:

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

where t represents the date the license agreement became effective, $(\sum_{t-6}^{t}\sum_j \tilde{C}_i \cdot \rho_i)_c$ is the citation-weighted sum of firm i's patents applied for within six years of the date of the license agreement t and which belongs to the same primary patent class c as the licensed technology, and $(\sum_{t-6}^{t}\sum_j \tilde{C}_i \cdot \rho_i)$ is the sum of all citation-weighted patents issued to the firm j 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 for licensors and licensees. It ranges between 0 and 1, where 1 indicates that the technology is a core technology and that there is complete correspondence between the primary patent class of the licensed technology and the focal firm's technologies.

Technological Uncertainty. In line with the theory section, we use the underlying knowledge used to create the focal licensed technology to measure technological uncertainty. Recombining several "newly created" or recent bodies of knowledge within a technology is considered a proxy for greater uncertainty concerning the technology's development and trajectory compared to proven bundles of technologies/knowledge. This is in line with the idea that uncertainty is related to generative appropriability. Technological uncertainty is computed using the age of the backward citations in the licensed patents in our sample. We calculate the average age in months for all the backward citations in each of the patents in our sample, based on the date of application of the backward citation, and the date of the focal patent application. This is in line with prior studies investigating the uncertainty of technological trajectories. It has been used to capture temporal exploration, and the effect of "recency" in relation to new knowledge recombinations (Nerkar 2003, p. 214), and to define *emerging technologies* and distinguish between firms working primarily with old technologies, and firms working on the development of up to date technologies (Ahuja and Lampert 2001, p. 533). The rationale is that the more recent the knowledge used to create a new technology, the greater the related uncertainty. The opposite should hold also; i.e., that a new technology which is developed based on knowledge that has been available and in use for a long time should present a less uncertain future trajectory. To capture the effect of higher uncertainty, we invert this variable by multiplying by (−1) the average age of the backward citations in the focal patent.

Control Variables

Royalty Rate. 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.[3]

Exclusivity. Another important contractual condition is exclusivity. The inclusion of an exclusivity clause in a licensing contract implies that the licensor agrees to work with only one licensee, preventing other firms from acquiring the same technology (Somaya et al. 2011). An exclusivity clause has implications for both parties. For the licensee it provides an incentive to commit more resources and engage actively in exploiting the licensed technology. For the licensor it is a contractual mechanism to ensure commercial success from the deal. Given the value creation possibilities associated with this clause, we expect that the grant-back clause is more likely to be used in exclusive licensing contracts.

Downstream Assets. The decision to license out a technology is affected strongly by the licensor's product market complementary assets (Fosfuri 2006). To control for the effect of the licensor's downstream assets on the likelihood of the contract including a grant-back clause, we use the licensor's advertising/promotional costs (radio, television, print media) in the given year. While in the markets for technology, downstream assets have been shown to be associated negatively to licensing rates, we expect them to have a different effect on the inclusion of a grant-back clause. Having decided to license out a technology, possession of downstream market assets should make the licensor less concerned about its technology being overtaken by the licensee.

Licensee Size. To account for the effect of the licensees' characteristics on the likelihood of a licensing contract including a grant-back clause, we control for licensee's size using the total number of patents filed by the licensee in the years prior to the licensing deal.

Technological Overlap. The decision to include a grant-back clause might be affected also by the extent to which the licensor and licensee build on the same technological fields. We use the measure proposed by Jaffe (1986), which indicates the technological positions of firm A relative to firm B in terms of the technology classes in which they have patented. This measure takes values between 0 and 1, with higher scores indicating a higher degree of overlap between the firms.

Same Sector. Based on industry and firm information extracted from Recap, we compute a dummy variable that takes the value 1 if licensor and licensee operate in the same sector (biotech, pharma, medical) and 0 otherwise. In line with previous studies (Choi 2002, Fosfuri 2006), we expect this variable to have a positive effect on the likelihood of a grant-back clause in the licensing contract.

Technological Superiority. The likelihood of a grant-back clause in a technology licensing contract may be associated with the licensee's and licensor's relative technological capabilities. Technologically superior licensors will have fewer incentives to include a grant-back clause, given that the recipient firm is unlikely to develop the technology at a rate or in a direction that would threaten the licensor in the technology or product markets. The licensor's technological superiority is measured as the difference between the logarithm of the licensor's and licensee's patent stock accumulated over the eight years prior to the licensing year. Positive values indicate that the licensor is technologically superior.

Patent Value. Following the convention in patent studies (Lahiri 2010, Trajtenberg 1990, Yang et al. 2010, Ziedonis 2007), we proxy the economic value of a technology with a time invariant measure of the total number of forward citations received by a patent from its date of publication to 2006, the latest year available in the NBER patent database at the time of the study. Patent value may introduce heterogeneity in the decision to enter the technology market.

Technology Radicalness. The radicalness of the technology is measured following Rosenkopf and Nerkar (1999) and is based on the total count of different three-digit level International Patent Classification (IPC) categories related to the patents cited by the patent for the focal technology, excluding the class of the focal patent. Backward citations referring to IPC classes other than its own indicate that the invention builds on several different technological fields (Shane 2001).

Technology Scope. Technology scope refers to the applicability of the technology, which may indicate 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 use the measure for scope proposed in Lerner (1994) that considers the number of IPCs that the USPTO assigns to a patent as an indication of the breadth of its technology base and intellectual property protection.

Technology Age. The age of the technology can influence the licensor's decision to commercialize it by exploiting it or licensing it out. 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). Therefore, firms will be less likely to commercialize more recent inventions, given that these technologies supposedly are at the technological frontier in terms of their inventive activities.

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 the Herfindahl index for the number of patents in firm i's patent portfolio, accumulated during the seven years before the license agreement. We operationalize this measure as follows:

$$\textit{Licensor technological specialization} = 1 - \sum_{j=1}\left(\frac{N_{jit}}{N_{it}}\right)^2,$$

where N_{it} represents the total number of patents granted to the licensor in the previous seven years, and N_{jit} is the number of patents assigned to the technology class j among the licensor's total patents in the same period. The final measure is calculated by subtracting 1 from the value reflecting the concentration of patent classes across different technology domains.

Licensor Market Diversification. We control for the number of different markets in which the licensor operates by counting the number of different standard industry classification (SIC) codes reported in the Compustat database at year t.

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

Firm Slack. The availability of slack resources can affect innovation novelty (Nohria and Gulati 1996). Given that the firm's ability to introduce highly novel innovations might affect the firm's licensing decision, we control for licensor i's slack, using the ratio of current assets to current liabilities in year t.

R&D Intensity. Relative R&D expenditure can affect technology licensing decisions. R&D intensive firms are likely to be less dependent on specific technologies, while less R&D intensive firms will likely have fewer technological opportunities (Dosi et al. 2006). Heavy investors in R&D are more likely to pursue technology-based strategies which do not include traditional commercialization, and to depend on intellectual property exchanges. R&D intensity is measured as the firm i's total of R&D investment divided by its sales in year t.

Sales Changes. Licensors that experience decreased sales may be under pressure to generate short-term revenue by licensing their more valuable technologies (Katz and Shapiro 1986). The percentage change in the licensor's sales in the licensing years t to $t-1$ is used to control for a licensing decision motivated by financial pressure.

Product Market Competition. To control for the effect of increased product market competition on the licensor's decision to license out, we use a Herfindahl index calculated on firm sales data. We exploit financial information from Compustat to identify firms operating in the same primary four-digit SIC code in a given year t. This takes account of the sales of all firms operating in the same industry, regardless of whether they are in our licensing sample. The index is calculated as follows:

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

where S_{ij} is the market share of firm i in industry j. We perform the above calculations for each year and each industry, and attach the resulting measure to the licensors. This measure has been used in previous studies (e.g., Hou and Robinson 2006, Lang and Stulz 1992) to measure the effect of product market competition on several dimensions of firm behavior. Also, licensing propensity varies across years and industry segments. To account for these effects, we include sector and period dummy variables.

Econometric Analysis and Model Choice

The dependent variable is a dummy representing whether the technology licensing contract included a grant-back clause. However, the grant-back clause cannot be considered independent of the likelihood that the technology is licensed-out. The two decisions are intertwined, producing binary independence between whether to license out a technology and whether to use a grant-back clause. Thus, we extracted all patents applied for by the licensor in the same year as the technology was licensed. We identified a total of 2,669 technologies of which 2,272 (approx. 85%) were not identified in Recap as being licensed out during the period 1984–2004. Among the 397 (approx. 15%) licensed technologies, 66 (just over 2%) were subject to a grant-back clause, and as a result, only 17% of our technology licensing contracts contain a grant-back clause.

We model the two binary variables as codependent, which allows us to test the hypotheses directly. We apply a hierarchical nested logit specification to model the likelihood that a grant-back clause will be included in the licensing contract. This type of specification splits the categorical values into "nests" of mutually dependent decisions (Manski and McFadden 1981) and enables joint estimation of the impacts of firm and technology characteristics on the licensing decision, and the decision to include a grant-back clause. We apply a two-level nested logit model with random utility maximization, and full information maximum-likelihood estimation. For similar nested logit model applications, see for instance Drucker and Puri (2005) and Ziedonis (2007).

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 USPTO patents granted to the licensor in the *same year* as the licensed technology, based on the assumption that they are included in the portfolio of technologies that the licensor potentially could offer on the technology market. To restrict the number of observations in the category *nonlicensed technology* to those technologies produced in the same period as the licensed technology, we focus on the patents produced in the same year by the same licensor. By including only patents produced in the same year we avoid concern that the first nest might be affected by changes to the firm's licensing strategy over time. The second nest includes *only* observations that have been licensed. The likelihood of the technology being licensed is estimated in the first nest; the likelihood that the technology license will include a grant-back clause is considered in the second nest.

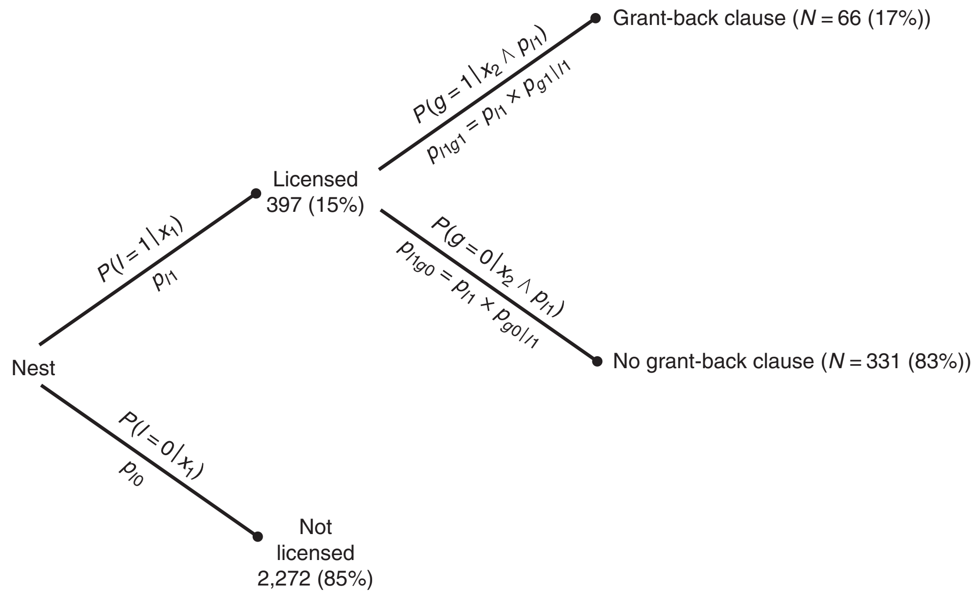
We investigate whether our assumption about binary dependence is justified by running a multinomial logistic regression on a three-level categorical variable (not licensed, licensed without grant-back, licensed with grant-back), and apply the Brant test which considers whether our assumption of independent irrelevant alternatives (IIA) is violated. We find strong evidence of violation of the IIA assumption when applying multinomial logit estimation, thus justifying the use of the nested logit specification.

Results

Descriptive Statistics and Correlations

Table 1 reports the mean, standard deviation, and minimum and maximum values of the variables and the sample; since nonlicensed technologies are not related to a contract those statistics refer only to the observations in the second nest of our model. The mean values are 0.51 for Licensor core technology and 0.09 for Licensee core technology. These statistics are in

Figure 1. The Hierarchical Nested Tree Structure



line with our expectations since the licensed technologies are more likely to be embedded in the licensors' than in the licensee's main technological activities. The variable technological uncertainty presents a mean of −131.37. Given that this variable is measured in months, this value corresponds to an average age of 11 years for the backward citations in the patents in our sample.

To investigate the nature of the grant-back clause further, we consider its use by different licensors and licensees. The data show that approximately 40% of the 81 licensors and 27% of the 117 licensees considered licensed at least one technology under a contract with a grant-back clause. Combined with the fact that only 17% of the technologies are licensed under contracts with a grant-back clause, these results indicate that among our sample, inclusion of a grant-back clause is not restricted to a small group of firms and is not standard practice among a select group. We interpret this as a first indication that grant-back clauses are included only in particular circumstances.

Table 1. Descriptive Statistics for the Contracts in the Sample ($N = 397$)

Variable	Mean	S.D.	Min	Max
Grant-back clause	0.17	0.36	0	1
Licensor core technology	0.51	0.34	0	1
Licensee core technology	0.09	0.21	0	1
Technological uncertainty	−131.37	119.55	−315.66	−1
Royalty rate	6.29	8.33	0	50
Exclusivity	0.73	0.45	0	1
Downstream assets	60.2	309.49	0	3,399
Licensee size	556.18	961.96	2	4,473
Technological overlap	0.33	0.34	0	1
Same sector	0.41	0.49	0	1
Technological superiority	0.27	3.77	−7.15	7.17
Patent value	42.26	115.69	0	1,555
Technology radicalness	2.46	2.83	0	18
Technology scope	2.44	1.55	1	17
Technology age	5	3.49	0	19
Licensor technological specialization	0.41	0.2	0.08	1
Licensor market diversification	2.96	3.74	1	34
Licensor size	5.79	2.37	1	11.49
Firm slack	7.02	37.48	154.77	526.85
R&D intensity	113.21	135.54	0.01	1,001.4
Sales change	3.19	18.28	0.01	343.32
Product market competition	0.79	0.21	0.21	0.95

Table 2 reports the Pearson correlation coefficients for the variables considered in the analysis ($N = 2{,}669$). None of the correlations raise concerns about multicollinearity in the regression analysis. This is confirmed by a variance inflation factor (VIF) analysis. The maximum VIF for any of the independent variables is 3.84 (mean VIF = 1.86).

Regression Results

Table 3 summarizes the results of the regression analysis. Model I reports the results considering only the controls and the direct effect of technological uncertainty; Models II–V introduce the explanatory variables and their interactions sequentially. The regressions provide support for Hypothesis 1 that the closer the technology to the licensor's core technological areas the more likely the contract will include a grant-back clause. Hypothesis 2 is supported across the models, with the coefficient of licensee core technology stable and statistically significant. We find support also for Hypotheses 3 and 4 on the moderating effects of technological uncertainty on the main relationships referred to in Hypotheses 1 and 2. We find evidence that increasing levels of uncertainty strengthen the

Table 2. Correlation Coefficients ($N = 2.669$)

Variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
[1] *Licensor core technology*	1										
[2] *Licensee core technology*	0.01	1									
[3] *Technological uncertainty*	−0.01	0.04	1								
[4] *Royalty rate*	0.00	0.07	0.07	1							
[5] *Exclusivity*	0.00	−0.09	−0.10	0.14	1						
[6] *Downstream assets*	0.01	−0.15	−0.16	−0.26	0.24	1					
[7] *Licensee size*	0.24	0.05	0.07	0.13	−0.10	−0.17	1				
[8] *Technological overlap*	0.10	0.22	0.22	0.05	0.14	0.01	0.15	1			
[9] *Same sector*	−0.02	0.05	0.05	0.23	0.09	−0.39	−0.24	−0.13	1		
[10] *Technological superiority*	−0.41	−0.08	−0.11	−0.10	0.09	0.26	−0.73	−0.38	0.23	1	
[11] *Patent value*	0.14	0.02	−0.03	0.08	−0.05	−0.1	0.04	0.02	0.06	−0.07	1
[12] *Technology radicalness*	0.04	0.03	0.06	0.02	0.01	−0.18	0.21	0.17	−0.08	−0.29	0.03
[13] *Technology scope*	0.20	0.05	0.05	0.04	0.00	0.02	0.08	0.08	0.04	−0.12	0.15
[14] *Technology age*	−0.33	−0.16	−0.16	−0.19	−0.13	0.13	−0.20	−0.27	−0.23	0.42	−0.03
[15] *Licensor technological specialization*	0.54	−0.01	0.01	0.15	0.00	−0.20	0.36	−0.02	0.13	−0.54	0.08
[16] *Licensor market diversification*	−0.13	−0.03	−0.03	−0.23	0.21	0.35	−0.17	0.10	−0.29	0.22	−0.08
[17] *Licensor size*	−0.34	−0.01	−0.03	−0.16	−0.07	0.55	−0.33	−0.22	−0.24	0.61	−0.10
[18] *Firm slack*	0.07	−0.01	−0.01	−0.01	−0.06	−0.05	0.01	0.01	0.05	−0.11	0.00
[19] *R&D intensity*	0.24	0.12	0.13	−0.02	0.19	−0.20	0.17	0.29	0.10	−0.38	−0.05
[20] *Sales change*	0.06	0.05	0.05	−0.01	0.09	−0.08	−0.01	0.12	−0.10	−0.16	−0.01
[21] *Product market competition*	−0.18	−0.02	−0.01	−0.31	0.09	0.25	−0.21	−0.05	−0.17	0.34	−0.21

Variables	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]
[13] *Technology radicalness*	1									
[14] *Technology scope*	−0.01	1								
[15] *Technology age*	−0.11	−0.15	1							
[16] *Licensor technological specialization*	0.16	0.11	−0.48	1						
[17] *Licensor market diversification*	0.09	−0.03	0.47	−0.38	1					
[18] *Licensor size*	−0.26	−0.12	0.43	−0.5	0.38	1				
[19] *Firm slack*	0.03	0.03	−0.08	0.12	−0.04	−0.17	1			
[20] *R&D intensity*	0.11	0.07	−0.41	0.34	−0.11	−0.47	0.01	1		
[21] *Sales change*	0.06	0.03	−0.11	0.07	−0.11	−0.23	0.01	0.14	1	
[22] *Product market competition*	−0.05	−0.16	0.33	−0.24	0.29	0.4	−0.05	−0.02	−0.07	1

positive effect of licensor's core technology on inclusion of a grant-back clause. The interaction between licensor core technology and technological uncertainty is positive and statistically significant at the conventional levels. The results reported in Table 3 support the idea in Hypothesis 4 about the positive moderation of uncertainty on the relationship between licensee core technology and the inclusion of a grant-back clause. The coefficient of the interaction between licensee core technology and technological uncertainty is positive and highly significant.

To check whether the moderating effects of uncertainty are robust to different proxies, we employ two alternative measures for technological uncertainty. First, we use as a proxy the rate of scientific references in the backward citations of the focal patents in a sample. This is based on the idea that the uncertainty associated to the technology will likely be higher if the underlying knowledge is at an early stage of development (Ziedonis 2007), and we argue that while "early-stage" technologies often are based on basic research (scientific knowledge), technologies closer to application include fewer citations to basic knowledge and more to other patented inventions (Narin et al. 1987, Rosenberg 1996). Table 3 reports the results using the rate of scientific backward citations as an uncertainty measure in Model VI. With the exception of the interaction between licensor core technology and technological uncertainty, the results are similar to those obtained using our primary uncertainty measure. To compute the second proxy for uncertainty (results not reported here for reasons of space), we examined each contract to identify the most advanced stage of development among the licensed technologies in Food and Drug Administration (FDA) trials based on data extracted from Recap. This information was used to create a dummy variable that is equal to 1 if the drug in a licensing contract was licensed before the clinical stage, and 0 otherwise (Banerjee 2012). A limitation of this measure in the context of the present paper is that we expect the measure to be more closely related to uncertainty related to product market commercialization of given products than to the future development and potential trajectory of the licensed technologies. The results obtained using this alternative measure were comparable (in sign and significance) to those based on average

Table 3. Nested Logit Results for Grant-Back Clause and Licensing Decisions

Variables	Model I	Model II	Model III	Model IV	Model V	Model VI
			Grant-back clause equation ($N = 397$)			
Licensor core technology		0.434***	0.422***	0.439***	0.451***	3.999***
		(0.134)	(0.134)	(0.136)	(0.136)	(1.326)
Licensee core technology			−0.344***	−0.335***	−0.426***	−4.780***
			(0.121)	(0.124)	(0.124)	(1.299)
Licensor core technology × Technological uncertainty				0.254**	0.272**	−2.543
				(0.115)	(0.116)	(1.683)
Licensee core technology × Technological uncertainty					0.197**	8.454**
					(0.090)	(3.811)
Technological uncertainty	−0.190+	−0.206+	−0.145	−0.145	−0.168	2.967***
	(0.098)	(0.109)	(0.108)	(0.110)	(0.109)	(0.717)
Royalty rate	0.039	0.035	0.026	0.019	0.025	0.020
	(0.031)	(0.032)	(0.029)	(0.028)	(0.028)	(0.031)
Exclusivity	0.846**	0.931**	0.837+	0.840+	0.841+	0.788
	(0.399)	(0.458)	(0.459)	(0.458)	(0.459)	(0.542)
Downstream assets	−0.000	−0.001	−0.001+	−0.001+	−0.001**	−0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Licensee size	0.002***	0.003***	0.002***	0.002**	0.002**	0.002+
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Technological overlap	1.973***	2.179***	2.455***	2.471***	2.692***	0.348**
	(0.662)	(0.692)	(0.712)	(0.706)	(0.732)	(0.160)
Same Sector	1.326***	1.382***	1.200**	1.200**	1.146**	0.933+
	(0.471)	(0.481)	(0.482)	(0.482)	(0.481)	(0.559)
Technological superiority	−0.208**	−0.177+	−0.162+	−0.164+	−0.185+	−0.311**
	(0.090)	(0.097)	(0.097)	(0.097)	(0.100)	(0.122)
			Technology licensing equation ($N = 2.272$)			
Technology characteristics						
Patent value	0.006***	0.005***	0.005***	0.005***	0.005***	0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Technology radicalness	0.038	0.041+	0.038	0.039	0.040	0.063**
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.026)
Technology scope	−0.042	−0.053	−0.051	−0.048	−0.047	−0.060
	(0.044)	(0.044)	(0.044)	(0.044)	(0.044)	(0.044)
Technology age	0.125***	0.134***	0.125***	0.124***	0.121***	0.131***
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Firm characteristics						
Licensor technological specialization	2.958***	2.522***	2.525***	2.546***	2.519***	2.417***
	(0.417)	(0.439)	(0.439)	(0.440)	(0.439)	(0.442)
Licensor market diversification	−0.022	−0.024	−0.024	−0.021	−0.017	−0.022
	(0.022)	(0.022)	(0.021)	(0.021)	(0.021)	(0.021)
Licensor size	−0.164***	−0.145***	−0.138***	−0.135***	−0.125***	−0.129***
	(0.038)	(0.039)	(0.039)	(0.039)	(0.040)	(0.040)
Firm slack	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R&D intensity	0.045	0.036	0.038	0.040	0.040	0.028
	(0.057)	(0.058)	(0.057)	(0.058)	(0.057)	(0.058)
Sales change	0.002	0.003	0.004	0.004	0.004	0.004
	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
Product market competition	−0.960**	−0.873+	−0.935**	−0.943**	−0.982**	−0.856+
	(0.450)	(0.451)	(0.448)	(0.449)	(0.450)	(0.448)
Constant	−1.668***	−2.171***	−2.126***	−2.124***	−2.154***	−2.570***
	(0.353)	(0.389)	(0.397)	(0.398)	(0.395)	(0.489)
Number of observations	2.669	2.669	2.669	2.669	2.669	2.669
Log likelihood	−1,072.904	−1,065.224	−1,061.296	−1,058.746	−1,056.275	−1,053.107
Chi2	468.923***	378.558***	378.670***	373.762***	364.237***	320.190***
Likelihood ratio comparison		15.359***	7.856***	5.101***	4.942***	—

Note. 1. Period and sector dummies are used in the estimations but omitted from the table.
$^{+}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$ (2-tailed tests for all variables).

age of backward citations. However, using trial data as an uncertainty measure also has some empirical shortcomings. Given the way that trials information is reported in Recap, we cannot directly connect the licensed patents to different stages of the FDA approval process. However, the fact that the results of using both alternative measures point in the same direction as our main uncertainty variable strengthens our confidence in the results.

The results for the controls in the second nest (grant-back equation) suggest that licensors tend to use a grant-back clause when licensing out to firms operating in the same sector. Downstream assets appear to be negatively associated to the use of a grant-back clause, suggesting that licensors with product market capabilities are less concerned about the boomerang effect. There is also a negative association between use of a grant-back clause and a technologically superior licensor. The parameter for exclusivity remains positive and significant across Models I to V.

The results of the first nest (technology licensing equation) suggest that more valuable patents and older technologies are more likely to be licensed. At firm-level, the results indicate that it is technologically specialized and smaller firms that engage in the markets for technology. We find support also for the idea that increasing product market competition is negatively associated with licensing-out rates. These findings are in line with prior studies.

Margins of Main and Interaction Effects

To test whether including the main explanatory variables improves the model fit significantly, we use a log likelihood comparison test to compare the unrestricted and restricted models in Table 3. The statistics show that including the independent variables provides additional explanatory power regarding the inclusion of a grant-back clause in a licensing contract. We test also for whether the inclusion of the interaction terms (Hypotheses 3 and 4) adds further explanatory power to Models IV and V; the test statistics are significant.

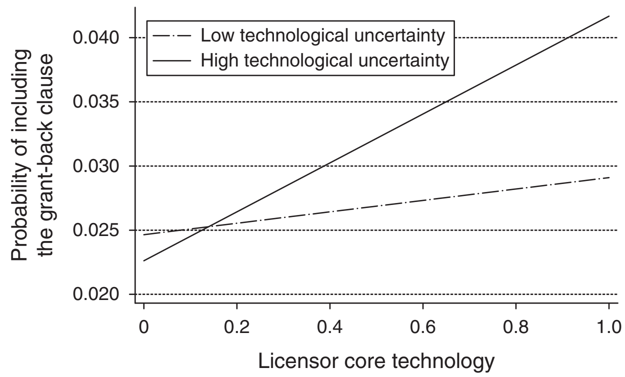
To assess the magnitude of the effect of a marginal change in the explanatory variables on the probability of observing a grant-back clause in a technology license contract, we estimate the average marginal effects. This requires partially differentiating the probability of a grant-back clause with respect to the explanatory variables. Since there is no standardized means of capturing marginal effects in a nested logit, we compute the marginal effects manually following the procedure suggested in Cameron and Trivedi (2009, p. 501): First, we predict the probabilities associated with the second nest using the observed values of the variables. We then calculate a new predicted probability for the second nest after adding a small increment to the focal variable (its standard deviation divided by 1,000). We obtain the difference between the two predicted probabilities and divide it by the same increment for each of the observations. Finally, we calculate the mean across observations for the focal variable to obtain the average marginal effect. We repeat these steps for all the variables of interest.[4] Table 4 reports the average marginal effects corresponding to the estimates in Model V (see Table 3). The marginal effects reveal that the small increase in the importance (core) of the technology to the licensor results in a 6% increase in the probability of a grant-back clause for the average observation. For the licensee it means a 5% decrease in the probability of a grant-back clause.

Table 4. Marginal Effects (*dp/dx*) from Table 3, Model IV

Variable	(*dp/dx*)
Second nest—Grant-back clause equation	
Licensor core technology	0.060
Licensee core technology	−0.056
Technological uncertainty	−0.000
Royalty rate	0.001
Exclusivity	0.020
Downstream assets	−0.000
Licensee size	0.000
Technological overlap	0.059
Same sector	0.028
Technological superiority	−0.004
First nest—Technology licensing equation	
Patent value	0.000
Technology radicalness	0.001
Technology scope	−0.001
Technology age	0.003
Licensor technological specialization	0.061
Licensor market diversification	−0.001
Licensor size	−0.003
Firm slack	0.000
R&D intensity	0.000
Sales change	0.000
Product market competition	−0.023

We supplement the marginal effects to further investigate the moderating effects by providing graphical representations of the effects. Figures 2 and 3 provide representations of the moderating effect of uncertainty on the relationship between both licensor and licensee core technology and the probability of including a grant-back clause. To compute the graphs, we split technological uncertainty into five categories and use the observations in the first and the fifth categories to plot high versus low levels of technological uncertainty. Figure 2 shows that as uncertainty increases, the positive effect of licensor core technology on the probability of including a grant-back clause turns more positive. Also, as uncertainty increases, the negative association between licensee core technology and the probability of a grant-back clause moves in a less negative (positive) direction (see Figure 3).

Figure 2. The Moderating Effect of Technological Uncertainty on Licensor Core Technology

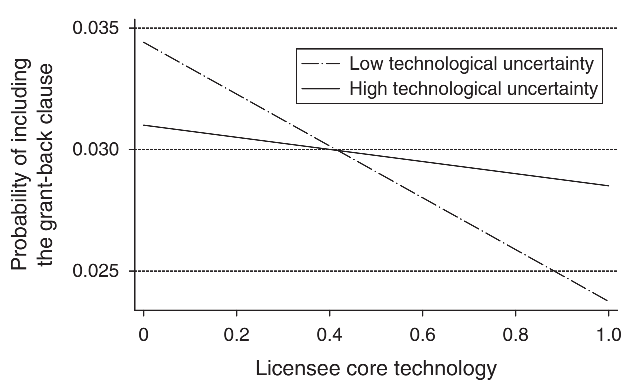


Sensitivity Analysis

Additional analyses ensure that results are not byproducts of our empirical choices. First, we consider those variables with a time window, and vary the time dimensions (±2 years). We find no evidence that these choices have an impact on the model's overall results.

We consider also that some firms appear more than once in the data set since they licensed-out more than one technology. This means that not all observations are independent of one another, which potentially could introduce some bias in our estimates. Although the descriptive statistics would suggest otherwise, it might be standard practice for some firms to include grant-back clauses, rather than being the result of circumstances in a random sample of observations. Thus, some observations may not be independent. To avoid this potential source of bias, we run a nested logit model with bootstrap specification; the bootstrap procedure mimics the fact that the data are a pooled cross section in which the reappearance of the same contractual partner is a random draw, not an endogenous event. The results are similar to those from the main analysis suggesting this potential source of bias is of limited concern. Finally, the potential lack of independence among observations could lead to underestimated standard errors. To confirm whether the main results are spuriously significant due to correlated data, we reestimate the models clustering the error terms at licensee level and then at licensor level. The size and significance of the coefficients are comparable with the reported results.

Figure 3. The Moderating Effect of Technological Uncertainty on Licensee Core Technology



Conclusion and Discussion

We began by discussing the boomerang effect proposed in the theoretical technological licensing literature. We examined the effect of the match between licensed technologies, licensors' and licensees' characteristics, and the type of technology, on the probability of including a grant-back clause in the licensing agreement. Building on concepts and insights from the innovation and appropriability literatures, we proposed theoretical arguments related to the contracting firms' need to protect their core technological resources, and firms' incentives to invest in developing the focal technology. 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 argued also that technology licensing agreements involving technologies that are core to the licensor and are uncertain should further increase the probability of including a grant-back clause. We found empirical support for the idea that technological uncertainty positively (making it more positive) moderates the relationship between the proximity of a licensed technology to the core of the licensor's patent portfolio and use of a grant-back clause. Finally, we explored whether the decreasing likelihood of a grant-back clause in a technology licensing agreement involving a technology that is core to the licensee is partially offset by the licensed technology being uncertain. We found empirical support for this argument.

Our work provides two main contributions. First, we extend the theoretical understanding in the strategic management literature of the functioning of the markets for technology (e.g., Ceccagnoli and Jiang 2013, Fosfuri 2006) by theoretically identifying the future potential beneficiaries of a licensing relationship that precludes potentially mutually beneficial deals. We show that undesirable potential rents accruing to licensing partners can be prevented by appropriate contract design. In other words, we provide further evidence that the design of contracts matters for firm behavior. Firms not only learn how to contract over time (Mayer and Argyres 2004, Poppo and Zenger 2002, Ryall and Sampson 2009), they include provisions to encourage the contracting parties to focus on creating joint value rather than squeezing out private benefits (Malhotra and Lumineau 2011). We show that firms use an important control provision related to firm-specific vulnerabilities pertaining to the technologies that are particularly important for firms' ability to create value in the longer run, and that firms factor in the technological uncertainly associated to the licensed technology. Moreover, the previous literature focuses almost exclusively on licensing problems from the licensor's perspective; we contribute by including licensors and licensees in the same conceptual and econometric model. Also, previous research on technological licensing mostly investigates how firms can protect their current technology and value-generating activities (primary appropriability) through the use of appropriability mechanisms such as patents (Ceccagnoli 2009, Cohen et al. 2000, Oxley 1997, Teece 1986). We contribute by demonstrating that not only do firms strive to generate value by investing in technological resources and means for appropriating returns from their current inventions, buyers and sellers of technological services try also to protect their potential future sources of value generation (generative appropriability) using contractual means.

Second, but related to the latter point, we extend the generative appropriability literature by specifying how firms can both harm (arguably the focus of Ahuja et al. 2013) and enhance the focal firm's generative appropriability through technology-related activities depending on contract design. This argument is in line with work on selective revealing (Alexy et al. 2013, Harhoff et al. 2003), and reabsorption of knowledge spillovers (Alnuaimi and George 2016, Yang et al. 2010). In the case of licensing, our results are consistent with the idea that the inclusion of a grant-back clause allows the licensor to enhance its generative appropriability by exploiting the efforts of the licensee and will be more likely to do so if the licensed technology is in an area where the licensor has substantial technological experience. Inclusion of a grant-back clause can enhance the licensee's generative appropriability in noncore areas by encouraging joint efforts with the licensor.

The findings from this study have implications for managerial practice. Licensing potentially is useful to increase the rents from innovation for both licensees and licensors. However, as we argued in the introduction, many potential transactions are hampered by market imperfections in a highly uncertain environment which provides few safeguards. Our research suggests that some of these problems can be resolved by an appropriate contract design which takes account of these transactional difficulties. Our research suggests also that licensors and licensees should be especially concerned about contract design if the traded technology is uncertain, and if it is related to core technologies that underpin the firms' generative appropriability.

This study has several limitations. First, testing the hypotheses developed in this paper requires an empirical setting in which the market for technology suffers from little friction. The pharmaceutical industry is specific in that licensing contracts frequently are used to trade knowledge and technologies. The mechanisms described in this paper may not apply to other industries where licensing is less common. This limitation suggests opportunities for future research. Second, due to the need for consistent financial information our empirical setting is restricted to public licensors. This prevents generalization of the results to small firms whose reasons for including a grant-back clause when licensing out may be different. However, our setup helps to remove unobserved heterogeneity related to firm size which otherwise might be a problem. Third, firms may choose not to disclose certain licensing deals for secrecy and strategic reasons in which case, selection issues might affect the representativeness of our database. However, we have no reason to expect that if firms choose not to report certain deals those unreported observations should be correlated systematically with the dependent variable. Fourth, our licensing data set does not allow us to identify whether licensors and licensees have relationships that extend the scope of the licensing deals. For example, it is possible that the deals in our sample could be one dimension of a supplier-buyer relationship. Although we believe that the number of firm- and market-level control variables in our econometric models minimizes this limitation, extending the analysis to involve other modes of interaction between licensing partners would be an interesting direction for future research. It might provide insights for managers involved in decisions about how to manage and design technology commercialization agreements.

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Endnotes

[1] In addition, a core technology often underpins a number of goods in the product market (Granstrand et al. 1997). This implies that the firm is particularly vulnerable to primary appropriability if it concerns a core technology.

[2] We tested whether these exclusion criteria were likely to have an impact on the overall result by comparing the mean values of the main explanatory variables for observations, which allowed us to calculate these variables. We found no reasons for concern.

[3] Royalty rates and a grant-back clause may be integral to the contractual negotiation and normally would require a modeling approach

that accounts for simultaneity in their determination. This would redefine the royalty rate from a control to an endogenous variable. Since our focus here is not on royalty rates, and because these two variables exhibit very low levels of correlation (Pearson correlations and Chi2 test statistics in a 2×2 matrix), we do not choose this approach.

[4]This method ensures that the marginal effect is based on the standard deviation of the explanatory variable and not a one-unit change, which raises concern for variables ranging between 0 and 1—the "core" variables and the uncertainty variable.

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