Contractibility and Contract Design in Strategic Alliances*

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PRELIMINARY AND INCOMPLETE.

COMMENTS VERY WELCOME.

Abstract

The widespread use of strategic alliances between pharmaceutical and biotechnology companies is puzzling, since it is hard to contract on the exact nature of the research activities. A major concern of pharmaceutical companies entering strategic alliances is that the biotechnology firm will use the pharmaceutical company's funds to subsidize other projects or substitute one project for another. Using a new data set on 584 biotechnology strategic alliance contracts, we find that the parties respond to the above contracting problem by assigning the unconditional right to terminate the alliance, including the reversion of intellectual property rights, to the pharmaceutical company. We develop a model based on the property-rights theory of the firm that allows for biotechnology firm researchers to pursue multiple tasks. When research activities are non-contractible, we show that it is optimal for the pharmaceutical company to obtain the right to terminate the alliance and to receive the property rights to the terminated project. This right will induce the biotechnology firm researchers not to deviate from the proposed research activities. The contract prevents opportunistic exercise of this termination right by specifying payments triggered by the termination of the agreement. Testing the model empirically, we find that the assignment of termination and product reversion rights to the financing firm occurs in contractually difficult environments in which the parties are unlikely to be able to specify the lead product candidate. We employ further empirical tests to distinguish the property-rights explanation from alternative stories, based on uncertainty and asymmetric information about the project quality or research abilities.

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I. Introduction

Biotechnological research frequently takes the form of strategic alliances between pharmaceutical and biotechnology companies. In a successful strategic alliance, the pharmaceutical company provides the initial financing, manages marketing and sales, and reaps most of the profits from the final project. The biotechnology company provides the research and receives the intellectual property rights. When entering the alliance, however, the interests of the two partners are typically not fully aligned. While it is the objective of the pharmaceutical company to develop a certain viable and profitable drug, the biotechnology firm has multiple interests. On the one hand, the researchers in the biotechnology laboratories are also interested in developing the proposed drug and ensuring future cash flows. On the other hand, they are typically juggling several research projects, either in other alliances or research that the firm intends to develop alone. Moreover, researchers in biotechnology firms are typically more academically oriented than pharmaceutical firms and may focus on different types of research even within the alliance project. The risk that the biotechnology researchers take money from the pharmaceutical company, but spend their time and effort on projects and ideas other than those agreed upon is in fact a major concern of pharmaceutical companies entering strategic alliances and has been termed "project substitution" or "project cross-subsidization."

In this paper, we analyze how strategic alliances address this incentive conflict. We find that the contracting parties often endogenously generate decision rights to govern the relationship when the lead product candidate is unspecified and it is thus not possible to contract on the exact nature of the research activities. These decision rights give the pharmaceutical company the unilateral and unconditional right to terminate the strategic alliance while continuing to have access to the intellectual property of the research project. Pharmaceutical firms often assert that the only remedy to these situations is to have the right to terminate the alliance. No matter how carefully constructed the alliance contract, they argue, constructing a transaction that forestalls all contingencies is impossible. As a result, firms pay an enormous amount of attention to negotiating the right to terminate alliances. In fact, these terms have been described as "probably the most heavily negotiated (at least in terms of time) provision" (Somers (2003)).

We develop a model based on the property-rights theory of the firm, in particular Hart and Moore (1988) and Nöldeke and Schmidt (1995), that allows for multi-tasking of biotechnology researchers in the sense of Holmström and Milgrom (1991) and that explains the observed contract design. We interpret the termination and product-reversion clauses as an

endogenously generated decision right that allows the pharmaceutical company to act upon an observable but not verifiable variable, namely research effort. The optimal contract specifies payments conditional on termination and continuation to ensure that the pharmaceutical company terminates if and only if the biotechnology company diverts effort from the alliance project into other projects. It also specifies that, in case of termination, the intellectual property rights revert to the pharmaceutical company, since the financially constrained biotechnology firms cannot compensate the pharmaceutical company for continuation payments ex ante. Still, due to the financial constraints of the biotechnology firm, the pharmaceutical company will typically extract less profit than in a complete-contracts world, in which it can contract directly on the type of research activity. Thus, whenever it is possible to contract on details of the research to be undertaken by the biotechnology company, the pharmaceutical company will rather employ such a complete contract in lieu of termination rights.

The predictions of this incomplete-contracts interpretation of the empirical contract design are born out in the empirical analysis. Alliances employ the termination and reversion clause whenever the exact nature of the research cannot be contracted upon. Moreover, the effect is strongest among the most financially constrained firms, as predicted by the model.

We employ additional empirical tests to distinguish the incomplete-contracts hypothesis from other explanations of the correlation between the lack of a contractually specified lead product candidate and the termination and reversion clauses. A number of the alternative explanations, such as heterogeneity in the extent of uncertainty, informational asymmetries, or incentive misalignment, also rely on the assumption of contractual incompleteness and thus may appear to support the basic hypothesis. We devise tests to address several classes of alternative explanations.

Overall, this paper serves three purposes. First, we shed light on a key incentive conflict in strategic alliances, project cross-subsidization. The nature of this incentive conflict differs from the classic hold-up problem with relationship-specific investments, and we relate it to moral hazard in a multi-tasking framework. Second, we provide new details of the empirical contract design in strategic alliances. In particular, we point to the frequent use of unilateral and unconditional termination and product reversion rights. Third, we offer an explanation how the combination of termination and product reversion rights may remedy the incentive problems and contracting difficulties of the alliance partners. Our explanation is based on the assumption of contractual incompleteness, which appears to be plausible in the context of research alliances.

While our empirical application is strategic alliances, we believe that termination rights (and payments) combined with product reversion may be used in other settings to remedy limits to contractual complexity. Venture capitalists typically provide capital in stages and have the right not to refinance a firm, which Gompers (1995) and other have attributed to the difficulty of writing a contract that foresees all contingencies. Not providing any refinancing is often essentially equivalent to driving the company into bankruptcy, in which case the venture capitalist (who as a preferred stock holder is a senior claimant) ends up owning all the assets. A second example, which can be given a similar interpretation, is the rising age-earnings profile in companies. The increase helps insure that employees perform as their firm would like them to, given that employment contracts cannot specify all work-related contingencies ex ante. In fact, firms face a similar problem of financial constraints on the side of the employees as pharmaceutical companies (with biotechnology firms). To both set incentives right and to allow the employer to extract the surplus from the employment relationship, employees would need to post a bond ex ante. Lazear (1979) interprets mandatory retirement as a substitute for such a bond given that employees are often unable to post it ex ante

Our paper builds on the incomplete contracts and property rights literature as pioneered by Grossman and Hart (1986), Hart and Moore (1988), and Hart and Moore (1990). In this literature, the actual information conditions that preclude writing complete contracts based on observable measures is a matter of some theoretical debate. As Tirole (1999) notes, the assumption of contractual incompleteness is generally accompanied by an invocation of transaction costs, specifically unforeseen contingencies, the cost of writing contracts, and the cost of enforcing contracts. We believe that the case of biotechnology strategic alliances without a specified lead-product candidate is well suited to illustrate the case of "too many" future contingencies that are "too hard to think of" to contract upon them.

Our paper attempts to test and provide evidence for the key insight of the property rights literature that the lack of contractibility of effort is remedied by assigning decision rights such as asset ownership. The previous literature addressing the property-rights literature of the firm empirically has focused on the "make or buy" decision (Baker and Hubbard (2003); Monteverde and Teece (1982)). We both add to the empirical evidence on incomplete-contracts theory and go beyond the previous empirical literature insofar as we focus on decision rights other than the standard property rights. In fact, our evidence suggests that, in situation where asset allocation is not feasible or would not be effective to solve the incentive problem, the contractual partners endogenously generate such a contractible decision right. Our model also deviates from the "classic hold-up case" in that, similar to Baker, Gibbons, and Murphy (2002), we do not focus on

relationship-specific investments. Rather, we consider, more generally, a multi-tasking environment à la Holmström and Milgrom (1991) that allows the biotechnology researcher to exert different types of effort.

Our paper differs in a similar manner from much of the previous work on strategic alliance and venture capital contracts. Most of the literature, such as Cornelli and Yosha (2003), Dessein (2003), Schmidt (2003), and Nöldeke and Schmidt (1998), focuses on the transfer of control rights between the contracting parties. In strategic alliances, however, the pharmaceutical company may be uninterested in owning the biotechnology firm. In fact, in contrast with the classic relationship-specific investment problem, the researchers of the pharmaceutical company may not be able to benefit from any residual control rights, simply because they do not have the relevant research expertise. Moreover, the pharmaceutical company is unlikely to have much interest in owning the entire biotechnology firm, but rather in developing one specific drug. Different from a venture capital firm, the pharmaceutical company does not want to maximize the value of the biotechnology company and is thus not interested in the transfer of ownership of the biotechnology firm (or relevant control rights).[1]

Our analysis builds upon the assumption that the relevant action – the research effort – is not transferable (here, to the pharmaceutical company) and, as in Hart and Holmström (2002), de-emphasizes the role of optimal ownership allocation. We do not relate, however, the non-contractibility of actions (or "decisions") to the boundaries to the firm. Rather, each party has a pre-determined role, and our model highlights how these parties optimally interact.

Finally, the specific incentive conflicts we point to are similar to those that have been analyzed outside of contract theory. The explosion of knowledge in biology and biochemistry in the 1970s triggered the adoption of the scientific institutions, or "open science" in Dasgupta and David's (1994) terminology, within for-profit organizations such as major pharmaceutical companies. (Henderson and Cockburn (1994); Gambardella (1995)). In particular, a number of firms encouraged researchers to pursue basic research, in addition to the applied projects that typically characterized these organizations. The firms that did so enjoyed substantially higher

[1] In one respect, our approach may be closest to Aghion and Tirole (1994). Similar to their work, our model suggests that financial constraints of the research unit may prevent the first-best outcome if research efforts are non-contractible, and that the allocation of product ownership helps to alleviate this problem. Our model corresponds to a situation in Aghion and Tirole where the research unit has higher marginal impact on the output, but the "customer" (i.e. pharmaceutical company) has all bargaining power. Our model, however, deviates from the Grossman and Hart (1986) setting employed by Aghion and Tirole in that we do not explore the impact of incentives and financial constraints on ex-ante product ownership, but rather on the "right to govern the relationship," in particular termination and product

R&D productivity than their peers, apparently because the research scientists allowed them to more accurately identify promising scientific developments and because the interaction with cutting-edge research made these firms more attractive to top scientists.[2] At the same time, the encouragement of "open science" processes has lead to difficulties in the design of incentive schemes, because of the very different outputs of each activity and means through which performance is measured (Cockburn, Henderson, and Stern, 1999). In fact, partly due to these challenges, firms appear to be moving to less of an emphasis on basic science in their research facilities (for a discussion, see Rosenbloom and Spencer (1996)).

The remainder of the paper is organized as follows. In Section II, we present stylized facts on strategic alliances, the incentive conflicts between alliances partners in the biotechnology sector and the empirical contract design. Section III presents a model that reconciles the empirical contract design with the observed conflict of interest. We test the predictions of the model empirically on a novel contracts data set, introduced in Section IV. The empirical results on our model predictions and alternative hypotheses are in Section V. Section VI concludes the paper.

II. Conflicts of Interest in Biotechnology Strategic Alliances

Innovative activities in the biotechnology have been increasingly financed via strategic alliances. As Lerner and Merges (1998) show, while the initial biotechnology companies relied primarily on capital raised from the public market, alliances surpassed public offerings in the 1990s as the dominant source of financing for these firms.

The alliance typically consists of two phases, a research phase and a marketing and sales phase. In a successful strategic alliance, the pharmaceutical company provides the initial financing, takes care of marketing and sales, and reaps most of the profits from the final project. The biotechnology company provides the bulk of the research, though employees of the larger firm may undertake some as well. As the dominant research-performing entity, the biotechnology firm often receives the intellectual property rights. Typically, the biotechnology firm commits to license the relevant patent holdings and know-how to its partner for the life of the agreement (and in many cases thereafter). The contract frequently delineates the right to

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reversion. The inefficiency implications of financial constraints, though, are of the same nature as in Aghion and Tirole (1994).

[2]Similarly, collaborations between university research labs and for-profit organizations are organized more often as sponsored research (instead of ex-post licensing) if more basic research is involved (Thursby and Thursby (2003)).

manufacture the product, which may be assign to one of the parties or the other, or divided between the two.

The widespread use of strategic alliances for biotechnological research is puzzling since it is hard to contract on research activities. Moreover, the interests of the two partners are typically not fully aligned when entering the alliance. We conducted a number of interviews with executives specializing in management, technology transfer, and legal affairs to clarify these issues, which highlighted that project substitution and project cross-subsidization by the biotechnology researchers is a major concern of pharmaceutical companies entering strategic alliances. While the pharmaceutical company aims to develop a certain viable and profitable drug, the biotechnology firm has multiple interests. On the one hand, the researchers in the biotechnology firm are also interested in developing the proposed drug in the collaboration and to ensure future cash flows. On the other hand, they are typically juggling several research projects. Some of these projects may be commercialized in collaboration with other pharmaceutical firms, on terms that may be more favorable than this collaboration. In addition, the firm may be seeking to develop wholly owned products, from which they will receive all the profits. Success in these solely developed products may also be particularly values by the equity markets as an indicator of the acumen of the firm's management. As a result, the biotechnology firm's researchers' may be tempted to employ resources from the alliance into other projects. These conflicts are in many cases almost inevitable: for instance, many biotechnologies have formed multiple alliances around a single compound, partnering with one firm to address one disease and with another to address a second. In these cases, it may likely to be very difficult to delineate the boundaries of each project.

In addition to these commercial conflicts, an addition challenge relates to the complex goals of the biotechnology researchers. Researchers in biotechnology companies are typically much more academically oriented than it is the case for the pharmaceutical company. Biotechnology firms often founded and guided by long-time academics who may still want to impact the academic discussion; they often employ post-doctoral students who are still considering an academic career in the future; and their reputation in the market for future alliances depends to a large extent on the external assessment of their research abilities. All these pressure may lead to biotechnology firms pursuing projects that are often more fundamental than the pharmaceutical company would prefer, and often seeking to publish these results before the pharmaceutical company prefers. These forms of conflict seem very important in this context, and have not been previously explored in the literature on strategic alliances.

A variant of this incentive problem is that researchers of the biotechnology firm tend to terminate unsuccessful projects too late. This can happen for several reasons. First, as described above, additional research on a given project can be beneficial to the researcher's scientific reputation even though it is not profit maximizing for the pharmaceutical company. Second, researchers and especially founders of biotechnology firms may be "attached" to the initial biotechnological component since it constitutes their principal discovery. Such behavior has been labeled "founder syndrome." In fact, whenever the initial technology researched is finally abandoned, founders often leave the company asserting that they do not "morally own" the company any more. Third, more generally, it appears to be hard for researchers to admit that a project ought to be terminated, thus, they tend to hold on to projects for too long.[3] Fourth, the researchers in the biotechnology companies may have empire-building preferences and thus attempt to maximize the number of ongoing projects.

These types of moral hazard problems are essentially variants of the project cross-subsidization problem laid out initially. The biotechnology researchers, rather than working on a different project than the pharmaceutical company would like them to work on, continue working on the actual or on a substitute project even though the pharmaceutical company would like them to declare the actual project to be terminated. Though we will focus on the incentive problem described above, these latter variants are basically reinterpretations of the (modeled) incentive problem.

An illustration of the possibilities of opportunistic behavior that can emerge from the behavior of the R&D firm in an alliance is the collaboration between ALZA, a California-based drug delivery company founded in 1968, and the Swiss pharmaceutical giant Ciba-Geigy. (This account is based on Angelmar and Doz (1987-1989).) The two firms formed a collaboration in 1978. ALZA also engaged in a variety of independent activities, including forming alliances to exploit technologies that did not conflict with the topics being jointly explored with Ciba-Geigy.

Due to ALZA's financial weakness, Ciba-Geigy was able to obtain vast control rights such as 8 of ALZA's 11 board seats, majority voting control, extensive information rights, and the ability to guide 90% of ALZA's research activity through a number of review boards that was dominated by Ciba-Geigy representatives. Nevertheless numerous tensions arose over the exact type of research the ALZA researchers should be conducting. The alliance failed three years later, mostly due to conflicts of project cross-subsidization.

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[3] Cf. Stulz (1990).

In particular, Ciba-Geigy was concerned about other alliances and research projects of ALZA. ALZA representatives kept seeking to establish collaborations with third parties. Ciba-Geigy found it difficult to control the activities of ALZA despite these seemingly ironclad control rights. While the boards ultimately approved most of these requests, ALZA representative became frustrated at the long delays associated with the process. As a result, ALZA scientists began bypassing the various review panels and began directly contacting senior Ciba-Geigy officials for permission to engage in outside arrangements or else (in the eyes of pharmaceutical company's liaisons with ALZA) deliberately obscuring their activities.

Meanwhile, information disclosure was a persistent sore point in the alliance. Ciba-Geigy officials believed that ALZA scientists were publishing materials in journals that would have been best reserved for the two parties in the alliance. Ciba-Geigy officials, worry that their proprietary technology might be disclosed in these publications or employed in ALZA's alliances with other pharmaceutical firms, began increasingly reluctant to disclose their own technologies in the area of drug delivery to ALZA. Ultimately, these tensions led to the dissolution of the alliance at the end of 1981. These conflicts, while perhaps extreme, illustrate the difficulties that the types of problems delineated above can have on parties.

III. Model

We present a simple model that illustrates the profit-maximizing contractual response to the incentive misalignment between biotechnology and pharmaceutical companies. The model allows us to explore how variations in contractibility affect the design of strategic alliances.

As in previous literature on incomplete contracts, in particular Hart and Moore (1988) and Nöldeke and Schmidt (1995), we consider situations where effort and (research) output are observable, but not verifiable.[4] However, rather than focusing on the much-analyzed specific case of relationship-specific investment, we employ a multi-tasking framework as in Holmström and Milgrom (1991), which captures a broader set of incentive conflicts. The biotechnology researchers have to allocate their efforts between "narrow" and "broad" research activities. For simplicity, we present the case of non-stochastic output. We will allow for uncertainty when considering alternative explanations of the empirical contract design.

Consider a biotechnology company and a pharmaceutical company who can jointly generate surplus via research collaboration. The biotechnology company is financially constrained. In particular, if the pharmaceutical company provides initial financing I–e.g., to set up a laboratory–then the biotechnology researchers can exert research effort and generate a biotechnological product that, with the marketing and sales efforts of the pharmaceutical company, will lead to profits.

We distinguish two types of surplus, the profit N from producing and selling the final product and additional surplus B accruing to the patent holder and owner of the intellectual property rights, such as the potential for related research and discoveries. The first type of surplus, N, depends mainly on the marketing and production effort of the pharmaceutical company. The biotechnology company lacks experience not only in clinical trials and the regulatory approval process but also in manufacturing, marketing, distribution, and sales. It is thus crucial that the pharmaceutical company takes care of this second phase of the alliance. Rather than modeling the second phase of the alliance and potential moral hazard problems explicitly, we assume that N is zero if it does not accrue to the pharmaceutical company. Throughout this section, N will thus only depend on the efforts of the biotechnology company and on the ownership of the pharmaceutical company.

The second type of surplus, B, is significantly smaller if the pharmaceutical company owns the patents. Patents are crucial assets for small biotechnology companies, both as a signal of the company's research abilities and quality and as starting point for future discoveries. Furthermore, while reputation in the scientific community may be highly relevant for the success of biotechnology firms and the careers of academically oriented researchers in these companies. We assume that in contrast, all a pharmaceutical company is interested in are the licensing rights.[5] We capture the efficiency loss as reduced surplus αB, $\alpha \in [0;1)$, if the patent rights revert to the pharmaceutical company.

Our analysis focuses on the effort exerted by the biotechnology company and the moral hazard problem of so-called "project substitution" or "cross-subsidization." The researchers can

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[4] The assumption that the research efforts are observable reflects that the fact—highlighted in our interviews—that pharmaceutical companies can (and do sometimes) insist on having their own researchers visit and monitor the lab of the biotechnology company.

[5] While this assumption may be extreme, it captures the substantially reduced importance of scientific prowess (as opposed to product-based and financial measures) that analysts use to assess pharmaceutical companies, as well as the lesser emphasis on publication in scientific publications at these firms.

exert effort either narrowly directed towards the objective of the strategic alliance, e_n, or more broadly, e_b. "Broad" research effort may prove useful for other (current or future) strategic alliances and enhance the scientific reputation of a researcher. For example, the researchers of the biotechnology company may run additional experiments to satisfy academic requirements for a publication in a top journal, even though there is already enough evidence to start the process for approval by the U.S. Food and Drug Administration for the drug envisioned in the alliance and the pharmaceutical partner would like to press ahead with the approval process. In the model, narrow and broad effort affect differently the two types of surplus, i.e.,

$$\text{argmax } N(e_n, e_b) \neq \text{argmax } B(e_n, e_b)$$

We will first consider the polar case that the researcher can exert either only narrow or only broad effort and has reservation utility $B(e_n, e_b)$: i.e., he wants to retain at least the value of the patent in order to exert effort. The pharmaceutical company has the bargaining power to extract all remaining surplus and demands at least the value of the initial investment I in order to enter the strategic alliance. We denote the value of patents for the biotechnology company that result from broad effort as $\overline{B}$ and the value of effort after narrow effort as $\underline{B}$ with $\underline{B} < \overline{B}$. The value of the final product of an (unterminated) strategic alliance is $\underline{N}$ after broad effort and $\overline{N}$ after narrow effort with $\underline{N} < \overline{N}$ and $\overline{N} > I$.

Contractible effort. As it is easy to see, in the case of contractible effort the pharmaceutical company will require the biotechnology researcher to exert narrow effort, assign the patent rights to the biotechnology researcher, and retain profits $\overline{N}$. Note that this is not necessarily the efficient outcome since $\overline{B} + \underline{N}$ may well be larger than $\underline{B} + \overline{N}$. The financial constraints of the biotechnology company prevent the parties from agreeing on the first-best and having the biotechnology company compensate ex ante, akin to Aghion-Tirole (1994).

Non-contractible effort. If effort and output are not verifiable and the parties cannot condition on any other variable, it may not be possible to form an alliance and generate surplus, namely when $\underline{N} < I < \overline{N}$. Reallocating asset ownership (intellectual property rights) does not improve the incentives, and making the biotechnology company the residual claimant is not feasible due to the biotechnology company's financial constraints. However, the parties may endogenously generate other decision rights to overcome the contracting problem. In particular, we consider the option right to terminate the relationship after the biotechnology researchers have

spent their research effort and before the final surplus N from marketing and sales is generated. If termination is verifiable, we can find a solution to the contracting problem if α is low enough.

Proposition. For $\overline{N} - I > \underline{N} - \alpha\overline{B} > 0$, any contract that assigns the right to terminate to the pharmaceutical company and the intellectual property rights to the biotechnology company in case of continuation and to the pharmaceutical company in case of termination and that determines continuation and termination payments p_C and p_T from the pharmaceutical company to the biotechnology company such that $\underline{N} - \alpha\overline{B} < p_C - p_T < \overline{N} - \alpha\underline{B}$ induces profit-maximizing research effort.

Proof. Any option contract with payments (p_C, p_T) such that $\underline{N} - \alpha\overline{B} < p_C - p_T < \overline{N} - \alpha\underline{B}$ induces the pharmaceutical company to terminate if the biotechnology researchers choose e_b (since $\underline{N} - p_C < \alpha\overline{B} - p_T$) and not to terminate if the biotechnology researchers choose e_n (since $\alpha\underline{B} - p_T < \overline{N} - p_C$). Anticipating this termination behavior, the biotechnology researchers choose e_n since $\underline{B} + p_C > p_T$.

From this set of contracts, the pharmaceutical company will choose the contract with the profit-maximizing prices $p_T = 0$ and $p_C = \underline{N} - \alpha\overline{B}$ (assuming that the pharmaceutical company terminates if indifferent between termination and continuation). The total payoff of the pharmaceutical company is $\overline{N} - I - (\underline{N} - \alpha\overline{B}) > 0$ and the total payoff of the biotechnology company is $\underline{B} + \underline{N} - \alpha\overline{B}$.

The simple model illustrates that the conflict of research interests between the pharmaceutical company and the biotechnology company may prevent the parties from forming an alliance and generating surplus whenever the exact nature of the research activities is not contractible. For a reasonable range of parameters, however, the parties can overcome this problem by assigning the unilateral and unconditional right to terminate to the pharmaceutical company. To prevent opportunistic exercise of this right, payments conditional on termination and continuation need to be specified. Given the financial constraints of the biotechnology company and the necessary difference between continuation and termination payments, the pharmaceutical company cannot extract the full profit $\overline{N} - I$ any more. If the biotechnology company were not financially constrained, the termination contract would allow the

pharmaceutical company to extract the full surplus and may be employed regardless of the contractibility of research efforts.

The model thus yields two main predictions:

Prediction 1. If the research activities of the biotechnology company cannot be contracted upon, the strategic alliance contract assigns the right to terminate with reversion of property rights to the pharmaceutical company.

Prediction 2. While strategic alliances contracts with financially constrained biotechnology companies employ the termination clause with product reversion only if research is non-contractible, strategic alliance contracts with financially less constrained or unconstrained biotechnology companies may employ the clause with or without research contractibility.

In the remainder of the paper, we will test these predictions empirically. In addition, we will lay out alternative hypotheses for the correlation between the termination clause with product reversion and non-contractible research efforts. Further empirical tests, which account for variations in uncertainty, in informational asymmetry, in research abilities of the biotechnology company, and in the misalignment of incentive, allow us to distinguish between the alternative explanations.

IV. Data

To test how the contractual design responds to variations in contractibility and, in particular, to analyze different explanations for the prevalence of termination rights, we collected a novel data set of strategic alliance contracts. This section describes how we collected the sample and describes some stylized features about the strategic alliance contracts.

In undertaking this analysis, we sought to employ as large a sample of strategic alliances between biotechnology companies and commercial entities as possible. These partners are pharmaceutical companies, though some are with other (larger) biotechnology firms. We employed all agreements between 1980 and 2001 that had been analyzed by Recombinant Capital that met certain criteria discussed below.

Recombinant Capital is a San Francisco-based consulting firm that specializes (since 1988) in tracking contracts in the biotechnology industry. They prepare summaries of alliances that are either marketed directly to parties negotiating alliances seeking data on comparable transactions or used by Recombinant Capital's staff to prepare comparative studies of particular terms in these agreements. The summaries are based on filings with the U.S. Securities and Exchange Commission (SEC) and other regulatory bodies. These contracts are made public because the publicly traded firms are required by the SEC to file "material documents." Biotechnology companies tend to interpret this requirement conservatively, and often file the contracts specifying alliances as amendments to 10-K, 10-Q, S-1, or 8-K statements. In addition, a number of state governments require privately held companies with employee stock option plans to file "material documents," which are made available to the public. While some information in these agreements is redacted (not made publicly available), Recombinant Capital's staff culls through other SEC filings, news stories, and press releases in order to compile as much data as possible.

We eliminated a number of the summarized transactions in the Recombinant Capital database in an effort to minimize "undesirable" heterogeneity. The eliminated alliances included:

- Alliances involving universities, medical centers, other non-profit organizations, and government agencies.
- Alliances where one of the parties had a controlling interest in the other, either through a majority equity stake or through a purchase option (e.g. an alliance between a firm and one of its R&D limited partnerships).
- "Renegotiated alliances," i.e. we excluded cases in which the two parties had a previous alliance covering the same set of technologies.
- "Marketing-only alliances" i.e. alliances with neither a research nor a product development component.
- Alliances with more than two firms.

While a number of the above subsamples provide interesting variations on the conflict of interest, in particular an exacerbated contrast between scientific and commercial interests in the case of alliances with universities, the contract design in these alliances varies substantially, mostly reflecting institutional constraints. For examples, many universities require a minimum duration of financial support in order to be able to staff the project and set up other infrastructure. Also, the lack of trade secrets and the higher pressure to publish in universities induce additional caution on the side of the pharmaceutical companies, resulting in more protective contract design. Therefore, we eliminated the above subsamples and ended up with a total of 584 contracts. We carefully

examined the alliance contracts, and coded the key features of the greatest interest for our analysis (see discussion below).

Table 1 summarizes the feature of the alliances. The alliances range from 1980 to 2001, with a disproportionate representation of later alliances due to the growth of activity in the industry. The alliances range widely in length, averaging about four years.

We will wish to control for the quality of the biotechnology firms in the analyses below. Biotechnology companies may differ substantially in quality: for instance, the seasoning of the key executives and the scientific reputation of the advisors may differ sharply. These differences are difficult to parameterize, though. As a proxy, we will use the reputation of the investment banker who takes the biotechnology firm public: a biotechnology firm underwritten by Morgan Stanley, all else being equal, is likely to be a higher-quality firm than one taken public by D.H. Blair. We determine the ranking of the firm using the ratings compiled by Carter and Manaster (1990), Carter, Dark, and Singh (1998), and Ritter (2001). We use the rating the covers the particular time period when the firm went public. If the rating for that period is not available, we employ the rating in the most proximate period.

An area of special focus for us in the analysis below is the condition of the lead product candidate at the time the traction is signed. Recombinant Capital classifies these alliances using a 10-part scheme:

1. Discovery research: research program for which no lead product candidate identified
2. Lead molecule: a therapeutic discovery program for which a lead product candidate identified, but no testing has begun.
3. Pre-clinical: a therapeutic discovery program for which some animal data had been obtained (but no human trials yet)
4. Formulation: the research program not yet at clinical testing stage, but the project entails combining an approved or development stage drug with a vehicle or agent for the administration of such drugs
5. Other pre-clinical: research program not yet at clinical testing stage (employed for diagnostic or agricultural products).
6. Phase I: therapeutic development program for which Phase I (safety) human testing underway
7. Phase II: therapeutic development program for which Phase II (small-scale efficacy) human testing underway

8. Phase III/Field testing: therapeutic development program for which Phase III (large-scale efficacy) human testing underway OR an agricultural development program for which field-testing is underway.
9. PLA/NDA filed: research program where testing of the lead product complete and pending regulatory review
10. Approved: lead product has already been commercialized

The primary distinction we will make in our analysis is between projects with a well-defined (contractible) lead product candidate and those where only the research program has been defined, but discovery research is ongoing at the time that the alliance is signed. Our rationale is that in the latter settings (which represent 37.5% of the total), contractibility difficulties will be greatest. In supplemental regressions, we will estimate regressions contrasting projects with a well-defined and tested lead product candidate with projects where either only the research program has been defined (as before) or the lead product candidate has been defined, but is entirely untested (which together represent nearly 48% of the sample). The results are little changed.

In Table 1, we also present some summary data on the financial condition of the R&D. Most firms have only very modest revenues and financial resources, though there are a few positive outliers.

V. Empirical Analysis

We analyze the contractual relationship between non-contractibility and termination and product reversion rights. We face two choices regarding the nature of the dependent variable used in the analysis. Which provisions should be regarded as indicating whether the pharmaceutical company had termination and product reversion rights? And how should the dependent variable be measured?

We wish to determine the extent to which the pharmaceutical firm was granted the unconditional right to unilaterally terminate the agreement and obtain the rights to the product upon termination. While a wide variety of clauses allow the pharmaceutical firm to terminate the agreement, most of those are conditional on specific events, such as bankruptcy or acquisition of the biotechnology. To capture contractual remedies that are based on non-verifiability information, we focus on cases where the pharmaceutical firm can terminate the agreement without a clear trigger. Three cases appeared in the agreements we reviewed that met our criteria:

- When the pharmaceutical company can terminate the agreement for any cause, either within a defined time period (e.g., after one year of the alliance's signing) or at any stage of the alliance.
- When the pharmaceutical firm can terminate the alliance for "misbehavior" or "breach" of the agreement.
- When the pharmaceutical company believes the continuation of the alliance would be "unwise."

As noted in Table 1, termination rights appear to be a widespread feature of contracts. In almost all contracts some kind of termination right is specified (97.7%) and is assigned to the financing company or both parties (96.7%). More than half of those termination rights are conditional on specific events, while about 39% of the alliances have provisions for the financing firm to terminate the alliance unconditionally. In 11%, the financing firm has both termination rights and the ability to take ownership to the intellectual property after the termination of the agreement.

As the theory above suggests, we are interested in contractual provisions that exclude the biotechnology company from retaining all the value generated during the collaboration if the alliance is terminated. This is the case when the intellectual property rights revert to the pharmaceutical company. Arguably, patents and other intellectual property rights are worth less in the hands of the pharmaceutical company, and are thus always assigned to the biotechnology company if the alliance is successful. However, the threat of reversion enables the pharmaceutical company to ensure profit-maximizing research efforts on the part of the biotechnology researchers. We identify all situations where the pharmaceutical company retains rights to the intellectual property employed in the alliance after its termination. The interaction between this dummy variable and the four-part measure of termination rights will be the primary dependent variable in our analysis.

We construct the dependent variable in several ways. For instance, we use both a simple binary variable, which takes the value of one if the pharmaceutical company has at least one unconditional termination right (along with the product reversion), and a more refined integer variable, which accounts for the number of termination rights of the pharmaceutical company. In the latter case the dependent variable takes on measures from zero to +3. Furthermore, in light of alternative explanations for the right to terminate, both on the side of the pharmaceutical company and the biotechnology company, we consider only cases where the pharmaceutical company has the right to terminate (with product reversion) and the biotechnology company has no right to terminate (with or without product reversion). Again, we construct both the simple

binary variable, which takes the value of one if the pharmaceutical company has at least one termination right and the biotechnology company has none, and as well as integer variables with values from –3 to +3, counting the "net" termination rights of the pharmaceutical company minus those of the biotechnology company. All approaches deliver approximately the same results.

We begin by testing Prediction 1. The baseline regression analysis is reported in Table 2. We examine the extent to which projects without a contractible lead product candidate at the time the alliance is signed are more likely to involve alliance contracts that grant the pharmaceutical company the right to terminate the alliance while continuing to access the intellectual property involved. We employ a variety of control variables:

- We are concerned that there may be a time trend in the transactions, so we control for the date of the agreement. In the initial regressions, we employ a continuous date variable; in supplemental regressions, we use dummy variables for each year.
- Diagnostic and veterinary products are likely to face a substantially different information environment from therapeutic products. Not only are the scientific uncertainties often significantly reduced for a diagnostic product, but also the regulatory hurdles that both classes of products are considerably reduced.
- The cross-subsidization problems are likely to be potentially more severe if the biotechnology firm holds large number of closely related patents. We review the keywords in the abstracts of all awards to the biotechnology firm at the time the alliance is signed, and identify all related patents.
- Capital constraints may affect the transactions that the parties reach. In the baseline regression, we control for the amount of time the firm has until it runs out of cash. In particular, we take the absolute value of the ratio of the firm's current cash flow to its cash in hand. If the firm is profitable, we code this measure as zero. A higher value implies that it is sooner until the firm runs out of money.
- Previous alliances may ease the contracting between the two firms. In particular, the reputational capital that the two parties built up in previous alliances may allow firms to overcome problems that would be difficult to contract around if the parties suspected each other of being opportunistic.

The table presents a number of regressions, which use some or all of these independent variables. In addition, we employ both ordinary least squares and ordered logit specifications, which may better reflect the ordinal, non-negative nature of the dependent variable. Finally, we employ fixed effects for each year instead of the continuous date variable.

Across the reported regressions—and the many dozens of similar though unreported analyses—we find a consistent pattern. Alliances that encounter considerable contracting difficulties at the time that the transaction is signed are associated with a substantial boost in the probability of ownership and termination rights being assigned to the pharmaceutical firm. This result is not only statistically, but also economically significant: the average coefficient across the four ordinary least squares regressions of 0.11 is significant relative to the mean of the dependent variable (0.15).

We then test Prediction 2 and examine the impact of financial constraints on the contract design. As noted in the introduction, our paper—in a manner similar to Aghion and Tirole (1994)—suggests that the financial constraints of the biotechnology firm (the research unit, in their parlance) may preclude arriving at the first-best outcome. We should thus anticipate that the relationship between the assignment of termination and product reversion rights to the larger firm and a non-contractible lead product candidate should be stronger among financially constrained firms.

The assumption that the biotechnology company faces financial constraints, implicit in the above theoretical analysis, is certainly appropriate for the vast majority of biotechnology companies. Our sample of biotechnology firms is peculiar, however, in that many firms have undergone an initial public offering and are thus relatively large and established firms. As a result, many of the biotechnology firms in our sample them are not subject to financial constraints to the same extent as a typical biotechnology start-up company. Since the systematic correlation between the assignment of termination and revision rights to the financing firm and a non-contractible lead product candidate depends on the presence of financial constraints, we now test whether this dependence is borne out in the data: i.e. whether our results are driven by contracts with those biotechnology firms that are (most) financially constrained.

To identify biotechnology firms that are capital constrained, we employ several simple approaches. In the reported regressions in Table 3, we divide the firms based on their net income in the year prior to the alliance being formed and cash and equivalents at the end of that year. Cases where the biotechnology firm has net income or revenue below that of the median firm (in 2002 dollars) are considered separately. We find that consistent with our hypothesis, firms that are below the median along these measures are the only ones that display a statistically significant relationship between the provisions of ownership and termination rights to the financing firm and projects that are especially difficult to contract upon. In alliances where the parties were above

the median on these measures, the coefficient on this variable is roughly half the size and not statistically significant.

Alternative explanations

Our proxy for contractibility is, naturally, noisy and leaves room for a number of alternative explanations. In this section, we consider what we believe to be the three main alternative interpretations of the observed contract design.

Research abilities of the biotechnology company. The contract design may be related to uncertainty or asymmetric information about the "type" of the biotechnology company. When entering the alliance, the pharmaceutical company cannot perfectly assess the research abilities of the biotechnology researchers with respect to the joint project and the chances of a successful collaboration. Termination rights allow the pharmaceutical company to end the relationship as soon as it has recognized the biotechnology partner to have relatively low ability. For this story to explain the results, the "unspecified lead product" variable would need to capture higher uncertainty about research abilities or collaboration success.

For two reasons, however, this is an unlikely explanation for the observed variations in contract design. First, this story lacks a reason why the pharmaceutical company should also want to obtain product reversion. Quite to the opposite, intellectual property produced by "low research types" is likely to be least attractive to the pharmaceutical company. In other words, for this alternative explanation to hold, our results would need to be driven by the termination right, and not by product reversion. To distinguish between this alternative and the incomplete-contracts hypothesis, we repeat the analysis above, now using a dummy denoting whether the pharmaceutical company has the right to terminate the alliance (again coded as 0 to +3) as the dependent variable, but without the interaction with the measure of reversion. We find in the first four columns of Table 4 that under various specifications, the difficulty of contracting has no significant impact on the assignment of termination rights by themselves.

We also attempt to control for the research abilities directly. To do this, we examine the underwriter who took the biotechnology firms public. We anticipate that those firms that went public with the highest quality underwriters are likely to be higher quality than those that did not. Following previous literature, we use a Carter-Manaster (1990) style score to proxy for underwriter reputation. Tables 2 and 3 indicated already that our results are independent of this control. In addition, we run separate regressions for firms ranked above and below the median on their Carter-Manaster (1990) score. We find in Table 5 that the effects are much stronger among

the high-quality firms, i.e., among the biotechnology firms that went public with the best underwriters. The result runs against the alternative hypothesis delineated above. If the difficulty of discerning the R&D firm's type was the critical consideration behind the use of these provisions, we might anticipate that the relationship between the assignment of termination and ownership rights to the financing firm and difficulty of contracting would be even stronger among the lower-reputation firms. Moreover, the above-median firms instead are not only likely to have higher abilities and better prospects, but should also benefit from the "certification" of their research abilities that is implicit in the underwriter quality. The high reputation rank of their underwriter should thus reduce the uncertainty about their "type" and render the termination and product reversion rights more dispensable. The empirical results of Table 3 suggest, however, that these considerations do not trigger the analyzed contractual clauses.

Variations in uncertainty, informational asymmetry, or incentives. The contractibility hypothesis put forward in this paper builds on misaligned research incentives and non-contractibility of research effort. We attribute the variation in contractual termination and reversion clauses to variations in contractibility, holding incentive conflicts, informational asymmetry, monitoring costs, *etc*. constant. Alternatively, variations in the latter variables may determine the implementation of termination and reversion rights. For instance, the parties may employ termination and product reversion rights whenever they are facing higher uncertainty about the outcome, or whenever the informational asymmetry between pharmaceutical and biotechnology company is higher, or whenever the incentive conflict between the parties is higher. Any of these alternative suggestions would build on a model where termination and product reversion rights help to solve the incentive problem, but do so at a cost. The cost may be lower profit extraction for the pharmaceutical company (due to financial constraints of the biotechnology firm). Or it may be the risk of opportunistic exercise of the termination right on the side of the pharmaceutical company. Then, the termination and product reversion rights are employed only if the incentive problem is "severe enough," i.e. if uncertainty, informational asymmetry, or the incentive misalignment are big enough.

Before we present additional results that attempt to distinguish between the alternative explanations and our hypothesis, it is noteworthy that all of these stories need contractual incompleteness as a key ingredient. If the parties could write contracts on the exact action to be taken by the biotechnology researchers or condition on all possible outcomes, termination rights would not be employed since they come at a cost relative to writing complete contracts. Thus, even under these alternative explanations our results provide evidence on the impact of contract design when actions or outcomes are non-contractible.

However, additional empirical results cast some doubt on these alternative hypotheses. One first indicator that variations in uncertainty or informational asymmetry are unlikely to drive all of our results is the regressions that control for the type of research program (therapeutic, diagnostic, and veterinary). As noted above, the scientific and regulatory uncertainty is substantially higher when the alliance is seeking to develop a therapeutic product. Nevertheless, we do not find a consistent, significantly positive correlation between the termination and reversion clauses and therapeutic products. Moreover, even if eliminate undesired heterogeneity in uncertainty and we examine only alliances focusing on therapeutic products, our baseline results go through as before, with a coefficient of 0.11 (and a standard error of 0.05)[6]

What may be related to uncertainty and informational asymmetry is the termination right per se, not bundled with product reversion. Going back to Table 4, where we analyze "termination rights only" as the dependent variable, we find no relation between unspecified lead product candidate and termination rights. However, we also find that termination rights are negatively related to diagnostic and veterinary products. To the extent that the parties face less uncertainty with these types of products or less informational asymmetry about the prospects of the research program, the table indicates that other types of termination clauses may well be driven by variations in uncertainty. At the same time, these "non-results" help us feel comfortable that the results on the termination rights with product reversion do not simply stem from the fact that the pharmaceutical company just learns the type of the biotechnology company over time.

In the last two columns of Table 4, we also undertake a regression analysis employing *specified* termination provisions: that is, those triggered by distinct events. We focus on four classes of provisions: those triggered by the bankruptcy of one of the firms, change in control of one of the firms, the termination of another agreement by one or both of the parties, and other pre-specified events. As before, we employ as the dependent variable the interaction between a count of the number of provisions present (between zero and four) and a dummy variable that takes on the value one if intellectual property reverts (at least in part) to the financing firm. Since our predictions are specific to the combination of unconditional termination rights and product reversion, we would like to make sure that not "any" of the other termination rights, combined with product reversion, have a similar correlation with the nature of the research program.

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[6] When we focus on diagnostic and veterinary products, however, there is no meaningful relationship between the difficulty of contracting and the assignment of termination and ownership rights to the financing firm. The latter result may either be due to the small sample size (less than one-fifth of the observations fall into either of these categories) or because researchers of the pharmaceutical company can closely monitor and direct the research activities.

The results are reported in the fifth and sixth columns of Table 5. In transactions without a specified lead product at the time the alliance is signed, there is no significant tendency for these termination and reversion rights to be more frequently assigned to the financing firm. This result is again consistent with our hypothesis: the termination and product reversion rights are a substitute for conditional contracting.

The above results address uncertainty and informational asymmetry. As mentioned before, one may also attribute the correlation between termination rights with product reversion and lead-product specification to variations in the degree of incentive conflict. In other words, research programs with unspecified lead product candidate are more likely to imply different research interests than those for which the parties have agreed on a candidate. Based on our conversations with practitioners, however, the opposite appears to be the case. A biotechnology company that enters an alliance with a pre-specified and potentially even tested product candidate is more likely to be involved in parallel alliances and simultaneous, related research projects, increasing rather than decreasing the scope for project cross-subsidization. Moreover, young biotechnology firms with early-stage products are most likely to have a strong scientific orientation, which may introduce additional conflicts.

Other endogeneity concerns. The above regressions provide additional support for our hypothesis. Nevertheless, we clearly cannot resolve all endogeneity concerns. For instance, a major concern affecting the entire empirical literature on strategic alliances is the (endogenous) choice to enter an alliance. The pharmaceutical companies entering into strategic alliances are likely to be different from those not entering alliances. These differences mayaffect the observed contract design. While there is no obvious reason why the endogenous entry decision would affect the empirical results reported above, we attempt to address at least part of the selection issue. In particular, we would like to make sure that our results are not driven by endogenous matching between low-ability research types and pharmaceutical companies who (opportunistically) insist on termination rights.

To address this possibility, we employ fixed effects for each pharmaceutical company in Table 6, thus holding the type of pharmaceutical companies constant. When we employ a variety of specifications, we still find a consistently strong relationship between the difficulty of contracting and the assignment of termination and ownership rights to the financing firm. These last results suggest that, for a given pharmaceutical company, the variation in termination and reversion rights is indeed related to the research program. The results also alleviate partly the

larger endogeneity concerns pointed out before. The occurrence of different types of contracts within the same pharmaceutical firm ensure that our results are driven by the fact that certain types of companies only enter alliances with specified lead-product candidates, while other types of companies only enter those without.

VI. Conclusion

Overall, the empirical evidence on contract design in strategic alliances provides an example of firms reacting to limited contractibility by designing decision rights and combining these with payments conditional on the exercise of the decision right. Our approach differs from the previous empirical literature following the property-rights approach in that we focus on a property right different from the allocation of asset ownership; in fact, it appears, that the parties endogenously "generate" a decision right to solve the problem of contractual incompleteness.

At the same time, part of the contribution of this paper is that we shed light on the nature of the incentive and contracting problem in strategic alliances, in particular the so-called problem of project substitution or project cross-subsidization. Moreover, we provide new details on the contractual design in strategic alliances, which are consistent with the theory proposed in this paper, but which also may be of interest for a better understanding of inter-firm organizations.

To be sure, the right to terminate is only one of a complex array of decision rights inherent in strategic alliances. But the analysis suggests the promise of combining theoretical and empirical approaches to understanding contract design.

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Table 1. Summary statistics. The sample consists of 584 contracts entered into between biotechnology and pharmaceutical companies or between biotechnology firms.

	Mean	*Stan. Dev.*	*Minimum*	*Maximum*
Year of agreement	1995.3	3.7	1980	2001
Length of agreement (years)	3.9	3.2	0.9	31.0
Carter-Manaster lead underwriter rank	7.7	2.0	1.0	9.0
No specifiable lead product candidate at time of alliance signing?	37.5%		0	1
Did agreement involve diagnostic product?	13.0%		0	1
Did agreement involve veterinary product?	5.3%		0	1
Total patents assigned to R&D firm at time of alliance signing	8.6	20.1	0	178
R&D firm's cash and equivalents at end of previous year	46.1	134.2	0	1452.4
R&D firm's revenue in previous fiscal year	17.6	44.9	0	523.2
"Burn rate"/cash in hand for R&D firm	3.2	17.6	0	295.5
Did agreement involve any termination rights?	97.7%		0	1
Did agreement assign any termination rights to financing firm?	96.7%		0	1
Can the financing firm unconditionally terminate the alliance?	38.9%		0	1
Does financing firm have termination and ownership rights?	11.3%		0	1

Table 2. Regression analysis of the financing firm's ability to unilaterally terminate the alliance and to retain at least partial ownership of the intellectual property in the alliance upon its termination. The sample consists of 584 contracts entered into between biotechnology and pharmaceutical companies or between biotechnology firms. The dependent variable is the number of specified termination and reversion rights of the pharmaceutical company. The independent variables in all regressions include the date of the alliance signing, dummies for whether the product was unspecifiable at the time of the alliance signing or involves a diagnostic or veterinary application, and the Carter-Manaster [1990] style rank of the leading underwriter in the firm's initial public offering. In selected regressions, the independent variables also include the count of the R&D firm's relevant patents at the time of the alliance signing, the ratio of the R&D firms' "burn rate" and its cash and equivalents at the time of the alliance, the count of previous alliances between the two firms, and dummy variables for the year of the alliance (not reported). The first two and last two regressions employ an ordinary least squares specification; the third and fourth, an ordered logit specification. Standard errors in brackets.

	Dependent Variable: Termination and Ownership Rights of Financing Firm					
Date of agreement	0.003	0.01	0.01	0.03		
	[0.01]	[0.01]	[0.04]	[0.04]		
No specifiable lead product candidate at time of alliance signing?	0.09	0.11	0.51	0.59	0.11	0.13
	[0.04]**	[0.05]**	[0.28]*	[0.30]**	[0.04]***	[0.05]***
Did agreement involve diagnostic product?	-0.10	-0.09	-0.86	-0.75	-0.10	-0.09
	[0.06]*	[0.06]	[0.54]	[0.54]	[0.06]*	[0.06]
Did agreement involve veterinary product?	-0.12	-0.13	-1.40	-1.37	-0.13	-0.13
	[0.09]	[0.09]	[1.03]	[1.04]	[0.09]	[0.09]
Carter-Manaster underwriter rank	0.01	0.01	0.01	0.04	0.01	0.01
	[0.01]	[0.01]	[0.07]	[0.08]	[0.01]	[0.01]
Related patents assigned to the R&D firm		0.001		0.01		0.001
		[0.001]		[0.01]		[0.001]
"Burn rate"/cash in hand for R&D firm		-0.0003		-0.004		-0.0004
		[0.001]		[0.01]		[0.001]
Number of previous alliances between two firms		-0.005		-0.004		-0.002
		[0.05]		[0.35]		[0.05]
Constant	-5.79	-10.29				
	[10.48]	[11.59]				
Year fixed effects	No	No	No	No	Yes	Yes
Number of observations	530	480	530	480	530	480
χ^2-statistic or F-statistic	2.44	2.03	10.23	12.15	1.09	1.06
R^2	0.02	0.02	0.02	0.03	0.05	0.06

* = significant at the 10% confidence level; ** = significant at 5% level; *** = significant at the 1% level.

Table 3. Regression analysis of the financing firm's ability to unilaterally terminate the alliance and to retain at least partial ownership of the intellectual property in the alliance upon its termination, divided by proxies for financial constraints. The sample consists of 584 contracts entered into between biotechnology and pharmaceutical companies or between biotechnology firms. The dependent variable is the number of specified termination and reversion rights of the pharmaceutical company. The independent variables in all regressions include the date of the alliance signing, dummies for whether the product was unspecifiable at the time of the alliance signing or involves a diagnostic or veterinary application, the Carter-Manaster [1990] style rank of the leading underwriter in the firm's initial public offering, the count of the R&D firm's relevant patents at the time of the alliance signing, the ratio of the R&D firms' "burn rate" and its cash and equivalents at the time of the alliance, and the count of previous alliances between the two firms. In the first pair of regressions, observations are divided by whether the firm has above or below the median net income; in the third and fourth, whether the firm has above or below the median cash and equivalents. All employ an ordinary least squares specification. Standard errors in brackets.

	Dependent Variable: Termination and Ownership Rights of Financing Firm			
	Measured on Net Income		Measured on Cash and Equivalents	
	Below Median	**Above Median**	**Below Median**	**Above Median**
Date of agreement	0.004	0.01	0.01	-0.003
	[0.01]	[0.01]	[0.01]	[0.01]
No specifiable lead product candidate at time of alliance signing?	0.15	0.07	0.14	0.07
	[0.07]**	[0.06]	[0.07]**	[0.06]
Did agreement involve diagnostic product?	-0.07	-0.07	-0.15	-0.004
	[0.09]	[0.09]	[0.09]*	[0.08]
Did agreement involve veterinary product?	-0.10	-0.13	-0.12	-0.09
	[0.13]	[0.13]	[0.12]	[0.13]
Carter-Manaster underwriter rank	0.02	0.01	0.01	0.01
	[0.01]	[0.02]	[0.02]	[0.01]
Related patents assigned to the R&D firm	0.002	0.004	-0.004	0.002
	[0.001]	[0.004]	[0.006]	[0.001]
"Burn rate"/cash in hand for R&D firm	-0.0002	-0.0003	-0.001	-0.09
	[0.002]	[0.002]	[0.001]	[0.06]
Number of previous alliances between two firms	-0.03	0.02	0.03	-0.01
	[0.07]	[0.09]	[0.11]	[0.06]
Constant	-8.47	-20.21	-28.57	6.48
	[22.19]	[14.85]	[16.20]*	[18.23]
Number of observations	247	233	235	245
F-statistic	1.36	1.09	2.08	1.14
R^2	0.04	0.04	0.07	0.04

* = significant at the 10% confidence level; ** = significant at 5% level; *** = significant at the 1% level.

Table 4. Regression analyses using alternative dependent variables. The sample consists of 584 contracts entered into between biotechnology and pharmaceutical companies or between biotechnology firms. The dependent variable in the first four regressions is the number of specified termination of the pharmaceutical company. The dependent variable in the fifth and sixth regressions is the number of specified provisions relating to the termination of the alliance in well-defined circumstances in which the intellectual property reverts (at least partially) to the financing firm. The independent variables in all regressions include the date of the alliance signing, dummies for whether the product was unspecifiable at the time of the alliance signing or involves a diagnostic or veterinary application, and the Carter-Manaster [1990] style rank of the leading underwriter in the firm's initial public offering. In selected regressions, the independent variables also include the count of the R&D firm's relevant patents at the time of the alliance signing, the ratio of the R&D firms' "burn rate" and its cash and equivalents at the time of the alliance, and the count of previous alliances between the two firms. The first two regressions employ an ordinary least squares specification; the third and fourth, an ordered logit specification. Standard errors in brackets.

	Dependent Variable:					
	Termination Rights of Financing Firm				*Specific Termination And Reversion Rights*	
Date of agreement	-0.004	-0.01	-0.03	-0.03	0.003	0.005
	[0.01]	[0.01]	[0.02]	[0.02]	[0.003]	[0.003]
No specifiable lead product candidate at time of alliance signing?	-0.11	-0.09	-0.29	-0.22	0.03	0.02
	[0.07]	[0.08]	[0.19]	[0.20]	[0.03]	[0.03]
Did agreement involve diagnostic product?	-0.28	-0.28	-0.87	-0.86	-0.04	-0.04
	[0.10]***	[0.10]***	[0.29]***	[0.30]***	[0.03]	[0.04]
Did agreement involve veterinary product?	-0.16	-0.17	-0.47	-0.45	0.06	0.01
	[0.15]	[0.15]	[0.41]	[0.42]	[0.05]	[0.01]
Carter-Manaster underwriter rank	0.02	-0.01	0.001	0.005	0.01	0.01
	[0.02]	[0.02]	[0.05]	[0.05]	[0.01]	[0.01]
Related patents assigned to the R&D firm		-0.0001		-0.002		-0.001
		[0.002]		[0.01]		[0.001]
"Burn rate"/cash in hand for R&D firm		-0.001		-0.002		0.0003
		[0.002]		[0.005]		[0.0006]
Number of previous alliances between two firms		0.01		0.08		0.03
		[0.09]		[0.21]		[0.03]
Constant	8.39	10.91			-6.90	-9.32
	[17.92]	[19.77]			[6.01]	[6.74]
Number of observations	530	480	530	480	530	480
χ^2-statistic or F-statistic	2.96	1.53	15.76	13.70	1.57	0.96
R^2	0.03	0.03	0.02	0.01	0.01	0.02

* = significant at the 10% confidence level; ** = significant at 5% level; *** = significant at the 1% level.

Table 5. Regression analysis of the financing firm's ability to unilaterally terminate the alliance and to retain at least partial ownership of the intellectual property in the alliance upon its termination, divided by proxies for company quality. The sample consists of 584 contracts entered into between biotechnology and pharmaceutical companies or between biotechnology firms. The dependent variable is the number of specified termination and reversion rights of the pharmaceutical company. The independent variables in all regressions include the date of the alliance signing, dummies for whether the product was unspecifiable at the time of the alliance signing or involves a diagnostic or veterinary application (the latter two dummies are used in the first pair of regressions only), and the Carter-Manaster [1990] style rank of the leading underwriter in the firm's initial public offering (in the second pair of regressions only). Observations are divided by whether the firm has above or below the median Carter-Manaster rank of the lead underwriter. All employ an ordinary least squares specification. Standard errors in brackets.

	Dependent Variable: Termination and Ownership Rights of Financing Firm	
	Measured on Underwriter Reputation	
	Above Median	**Below Median**
Date of agreement	0.005	0.001
	[0.01]	[0.01]
No specifiable lead product candidate at time of alliance signing?	0.13	0.04
	[0.06]**	[0.07]
Did agreement involve diagnostic product?	-0.14	-0.04
	[0.08]*	[0.09]
Did agreement involve veterinary product?	-0.12	-0.08
	[0.11]	[0.15]
Carter-Manaster underwriter rank		0.01
		[0.01]
Constant	-8.88	-2.03
	[14.84]	[14.61]
Number of observations	307	223
F-statistic	2.87	0.44
R^2	0.04	0.01

* = significant at the 10% confidence level; ** = significant at 5% level; *** = significant at the 1% level.

Table 6. Regression analysis of the financing firm's ability to unilaterally terminate the alliance and to retain at least partial ownership of the intellectual property in the alliance upon its termination, with pharmaceutical company fixed effects. The sample consists of 584 contracts entered into between biotechnology and pharmaceutical companies or between biotechnology firms. The dependent variable is the number of specified termination and reversion rights of the pharmaceutical company. The independent variables in all regressions include the date of the alliance signing, dummies for whether the product was unspecifiable at the time of the alliance signing or involves a diagnostic or veterinary application, and the Carter-Manaster [1990] style rank of the leading underwriter in the firm's initial public offering. In selected regressions, the independent variables also include the count of the R&D firm's relevant patents at the time of the alliance signing, the ratio of the R&D firms' "burn rate" and its cash and equivalents at the time of the alliance, the count of previous alliances between the two firms, and dummy variables for the year of the alliance (not reported). All regressions employ an ordinary least squares specification. Standard errors in brackets.

	Dependent Variable: Termination and Ownership Rights of Financing Firm			
Date of agreement	0.002	0.005		
	[0.01]	[0.01]		
No specifiable lead product candidate at time of alliance signing?	0.09	0.10	0.11	0.13
	[0.04]**	[0.05]**	[0.04]**	[0.05]***
Did agreement involve diagnostic product?	-0.10	-0.09	-0.10	-0.08
	[0.06]*	[0.06]	[0.06]	[0.07]
Did agreement involve veterinary product?	-0.11	-0.11	-0.12	-0.11
	[0.09]	[0.09]	[0.09]	[0.10]
Carter-Manaster underwriter rank	0.01	0.01	0.005	0.01
	[0.01]	[0.01]	[0.01]	[0.01]
Related patents assigned to the R&D firm		0.001		0.001
		[0.001]		[0.001]
"Burn rate"/cash in hand for R&D firm		-0.0003		-0.0003
		[0.001]		[0.001]
Number of previous alliances between two firms		-0.02		-0.02
		[0.05]		[0.05]
Pharmaceutical company fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	No	No	Yes	Yes
Number of observations	530	480	530	480
χ^2-statistic or F-statistic	1.30	1.28	1.04	1.03
R^2	0.04	0.06	0.07	0.09

* = significant at the 10% confidence level; ** = significant at 5% level; *** = significant at the 1% level.