

The Booth School of Business, University of Chicago

Financial Contracting in Biotech Strategic Alliances

Author(s): David T. Robinson and Toby E. Stuart

Source: *The Journal of Law & Economics*, Vol. 50, No. 3 (August 2007), pp. 559-596

Published by: The University of Chicago Press for The Booth School of Business,
University of Chicago and The University of Chicago Law School

Stable URL: <https://www.jstor.org/stable/10.1086/519811>

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at <https://about.jstor.org/terms>



JSTOR

The University of Chicago Press, The Booth School of Business, University of Chicago and The University of Chicago Law School are collaborating with JSTOR to digitize, preserve and extend access to *The Journal of Law & Economics*

Financial Contracting in Biotech Strategic Alliances

David T. Robinson *Duke University*

Toby E. Stuart *Harvard University*

Abstract

We analyze 125 strategic alliance contracts, all of which concern early-stage research at small biotechnology research and development companies. Staged investment is ubiquitous, but solutions to agency problems vary. The cycle of equity participation in alliances resembles what we observe in venture capital contracts: they involve convertible equity and sometimes contain antidilution provisions, warrants, and board seats. Contracts rights vary explicitly with the size of the equity stake. Contracts contain explicit provisions linking equity participation to subsequent initial public offerings and contain clauses designed to insulate both parties from multitasking problems. Contracts often specify provisions that are unobservable or difficult to verify, which suggests a role for expected litigation as an enforcement tool in contract design.

1. Introduction

Strategic alliances and joint ventures are a common organizational vehicle through which large firms engage in research and development (R&D). This is especially true in the pharmaceutical industry: survey evidence from the Pharmaceutical Research and Manufacturers of America (PhRMA) suggests that roughly 25 percent of the \$26 billion in United States-based, industrially financed, pharmaceutical R&D that occurred in 2000 took place in over 700 collaborative agreements with outside organizations. This fraction has tripled since 1991 and has grown 20-fold since 1981 (National Science Board 2000).¹

This research was funded by the Lang Faculty Research Fellowship Program of the Eugene M. Lang Entrepreneurship Center at Columbia Business School. We would like to thank Mark Edwards at Recombinant Capital for generously making his data available to us. In addition, we are grateful to Kenneth Ayotte, Alex Butler, Bengt Holmström, Wei Jiang, Andy Wong, and participants at Columbia University, the University of Kansas, the National Bureau of Economic Research Strategic Alliance Conference, and the Batten Young Scholars Conference for helpful comments. Sandhya Persad and Weigang Yuan provided expert research assistance. Any errors are solely our own. Toby Stuart is also at Harvard Business School.

¹ These figures omit international research and development (R&D) deals and alliances facilitated through programs such as the Advanced Technology Program. Thus, the true scope of alliance activity in this sector may be greater than suggested here.

[*Journal of Law and Economics*, vol. 50 (August 2007)]

© 2007 by The University of Chicago. All rights reserved. 0022-2186/2007/5003-0020\$10.00

While the financial and strategic importance of alliances is widely acknowledged, less is known about their precise contractual structure. What governance issues figure most prominently in alliance contracts? How do the bundles of incentives provided in financial contracts substitute for or complement one another? How do alliance contracts compare with other financial contracts, such as venture capital (VC) contracts, which are commonly used to finance investment activity in nascent firms?

To explore questions such as these, this paper conducts a detailed, microlevel analysis of strategic alliance contracts. Rather than test hypotheses from particular theories, our primary goal is to deepen our understanding of strategic alliances by developing a rich set of facts that describe contract design. As a result, we organize our analysis around the key features of alliance contracts rather than around specific theoretical arguments.

We study the detailed features of 125 contracts written between pharmaceutical and biotechnology firms during the 1990–98 time period. The data come from proprietary contract analyses provided by Recombinant Capital, a biotechnology industry analysis firm. These contract analyses contain all the data from the contracts filed with the Securities and Exchange Commission (SEC) but are supplemented with information culled from industry trade conferences, scientific meetings, and press releases. To limit the scope for differences in the underlying contracting environment to affect contract characteristics, we intentionally narrow the empirical focus to alliances for genomics-related research—research occurring at the very earliest and riskiest stages of drug development. In each of these deals, a large pharmaceutical firm (the client) sponsors research at a small (often pre-initial-public-offering [IPO]) biotechnology R&D firm (the R&D partner).

A deeper understanding of the key features of alliance contracts achieves several objectives. First, it improves our understanding of the organization of industrial R&D. Given that over \$1.6 trillion was spent on R&D through federal, academic, and corporate channels during our sample period, this objective is important in its own right (National Science Foundation 1998; 1996 dollars).

Second, a better understanding of the facts surrounding strategic alliance contracts enriches the already vibrant theoretical and empirical literature on interfirm contracting. Our sample comprises large deals occurring at the earliest stages of drug development, concerning the use of scientific techniques that were in their infancy during our sample period but were widely perceived to hold great promise. Because of the myriad uncertainties associated with these agreements, the contracts acutely reflect the incentive problems at the heart of collaborative R&D and therefore provide an ideal empirical setting in which to explore the predictions of a wide variety of theoretical models on incomplete contracts and optimal financial contracting.

Our analysis of these contracts uncovers several key facts about strategic alliances that highlight the interplay among contractual, relational, and property-rights-oriented control mechanisms. First, we find direct evidence that equity

stakes are used to allocate control rights in the alliance contract. The incidence and number of board seats vary in direct proportion to the size of the equity stake. Not only is there variation across contracts in the use of board seats with equity stakes, but there is also within-contract variation: many contracts vary the scope of control as a function of the stake size and place explicit limits on the total equity that the client can own in the partner.

Second, we find evidence of substitution between ownership and contractual control in alliance contracts. For example, contracts that involve the client taking equity positions in the target typically limit the scope of the termination provisions the client is granted. Third, we find evidence that firm reputation and contractual control are substitutes. Firms with stronger reputations in the community of alliance partners not only receive larger up-front payments as part of the deals they enter, they also write less detailed contracts and receive less project-level and firm-level oversight.

Finally, we find evidence that firms choose to contract on potentially observable actions that may be costly, perhaps even impossible, to verify. While this appears to contradict the spirit of many property rights formulations of contract design, which posit that agents do not contract on unverifiable actions, we think this suggests several important considerations. The first is that in a world of incomplete contracts, relational mechanisms are important for enforcing contract provisions. The second is that *ex post* litigation is a tool for contract enforcement. Vague contractual provisions are enforceable in practice because the courts rely on institutional standards for determining whether breach has occurred. Indeed, the contracts we analyze seem to bear out the idea expressed by Scott and Triantis (2005, p. 879) that “contracts can anticipate and harness the litigation process.” The frequency of such provisions in the data demonstrate the idea that it may be desirable to include unverifiable provisions in a contract because doing so raises contracting surplus by more than it increases transactions costs: either their inclusion is inexpensive *ex ante* or the cost of verification *ex post* varies with the state of the project in a manner that affects incentives or shapes the process of litigation in the event that disputes arise.

The role of alliance agreements as financing vehicles for small, high-tech firms invites a comparison with VC agreements, and indeed, biotech strategic alliances are structured like VC agreements. The biotechnology alliances in our sample typically state at the outset that investments will be staggered and contingent on certain milestones to capture the option value associated with abandonment or delayed expansion (Kaplan and Strömberg 2003).

Moreover, equity participation follows a distinct pattern related to the life cycle of the biotech firm. The youngest pre-IPO biotech firms receive no equity funding.² For older pre-IPO firms, equity stakes involve convertible preferred equity that converts to common stock at IPO. Firms turn increasingly to common over preferred equity as they mature or develop more connections to other firms

² See Wong (2001) for related evidence in the angel financing market.

in the industry. Equity purchasers typically receive registration rights and anti-dilution provisions, just as in VC contracts.

Nevertheless, there are critical differences between alliance agreements and VC contracts. These differences stem from the fact that while VCs fund the growth of firms as a whole, clients in strategic alliances sponsor projects inside firms. Thus, unlike what we see in VC deals, the client often does not receive board seats or other explicit, firm-level control rights in conjunction with its equity stake in the target. Instead, contracts uniformly put project-level control provisions into place.

It is interesting to note that these project-level considerations are precisely where we find evidence of contractual provisions that involve costly verification. For example, contracts often require a certain number of man-hours to be performed in various activities. Contracts are silent on how these activities are monitored, and discussions with industry insiders suggest that no explicit mechanisms exist to monitor these stipulations. In addition, contracts often state that the client should pursue the development of alliance-developed drugs with the same vigor that it shows its own drug candidates. Goldberg (2000) and other legal scholars have noted that such language can only be defined by the context of the business transaction, something that cannot be determined without litigation.

Yet this is exactly where contracts appear to harness the potential for future litigation (Scott and Triantis 2005). Contracts requiring the biotech firm to take unverifiable actions are more likely to allocate broad termination rights to the client. This allows the client effectively to terminate on the basis of observable but not verifiable information without breaching the contract, which in turn helps to shape the scope of expected litigation if it occurs. These considerations then affect both parties' *ex ante* incentives to uphold the contract.

This paper is part of a growing body of empirical work on financial contracting. The descriptive approach of this paper draws on the prior work of Sahlman (1990), Kaplan and Strömberg (2003), and Wong (2001). These prior descriptive papers explore financial contracts for early-stage investment activity in different settings and provide a natural point of comparison for the results we present here. We also add to earlier studies that examine the interaction between broadly defined control rights in contracts, such as Arruñada, Garicano, and Vázquez (2001). Similarly, Lerner and Merges (1998) and Lerner, Shane, and Tsai (2003) show how control rights vary with the availability of outside funding, and Robinson and Stuart (2007) find that reputation effects are important determinants of the allocation of control rights in biotech alliances. Finally, our analysis of the interaction of different modes of enforcement illustrates the importance of relational incentives and thus complements the theoretical work of Baker, Gibbons, and Murphy (2004), which studies how relational contracts work in an alliance setting.

The remainder of the paper is organized as follows. We begin in Section 2 with industry background and a discussion of the role of collaborative agreements

in pharmaceutical R&D. Section 3 describes the data in greater detail. Section 4 examines the cycle of equity ownership in strategic alliances, while Section 5 discusses the role of contract specificity, oversight, and prior experience in determining the allocation of control. Section 6 describes termination provisions. Sections 7 and 8 explore the trade-off among contract complexity, ownership rights, and relational considerations. Section 9 concludes by offering future theoretical and empirical research directions suggested by our findings.

2. The Structure and Scope of Collaborative Pharmaceutical Research and Development

While alliances occur frequently in a broad range of industries, they tend to cluster in risky, high-R&D settings (Robinson 2008). It is therefore unsurprising that alliances are a common method of organizing pharmaceutical R&D, since drug development is a highly risky and expensive endeavor. Indeed, data from Recombinant Capital indicate that thousands of strategic alliances among pharmaceutical firms, biotechnology research firms, and universities have been formed since the inception of the biotechnology industry in the early 1970s.

The pharmaceutical development process often begins with the identification and validation of drug targets, which are enzymes or receptors that trigger or block biochemical processes within a cell. Validated targets are then screened against (typically hundreds of thousands) molecules, with the aim of pinpointing compounds that trigger or block the disease processes. After a lead compound has been identified and screened, it goes through a number of testing stages. Before it is submitted to the Food and Drug Administration (FDA) to obtain clearance for human testing, it goes through animal testing for toxicity. Clinical testing consists of three phases. Phase I testing involves small numbers of healthy volunteers and seeks to determine safe dosage levels and toxicity. At phase II, the drug is tested for efficacy on large samples of patients whom the drug is intended to benefit. Finally, phase III trials entail a controlled experimental design and test for long-term adverse effects in large samples of human subjects. According to data from PhRMA, the total time involved from beginning of discovery-stage research to marketed drug is 10–15 years.

The odds of failure in this process are daunting. Data from DiMasi et al. (1990) suggest that for every 5,000–10,000 compounds that are identified, only 250 reach preclinical testing.

DiMasi, Hansen, and Grabowski (2003) find that only about 20 percent of drugs that begin phase I trials will be approved by the FDA. Moreover, securing FDA approval does not guarantee success. Grabowski and Vernon (1990) report that only one in five drugs introduced between 1980 and 1984 generated total revenues exceeding average, after-tax R&D costs of \$250 million (1990 dollars).

The precise nature of the interfirm relationship in an alliance varies according

to the stage of development.³ Many later-stage alliances simply involve one firm conducting FDA trials on behalf of the other. In these alliances, contracting problems are less severe because contingencies can be readily specified and outcomes are subject to external validation. In the alliances we examine, the R&D partner identifies and/or validates drug targets, which are then further developed in collaboration with the client. In some of the partnerships, the biotech partner will also screen compounds against targets and thus transfer lead development compounds to the client.

Although biotech firms continue to expand downstream in the drug development chain, the client in the partnerships we examine typically conducts animal testing, clinical trials, large-scale manufacturing, and sales and marketing. One can view this relationship as one in which the pharmaceutical client and the biotech firm engage in joint production: most alliances in biotechnology are vertical transactions in which there is an upstream-downstream division of effort between the biotech firm and the client in the deal. Alternatively, another way to view this relationship is that the pharmaceutical firm acts in a dual role as investor and consumer: as an investor it uses equity participation and payments for sponsored research to finance drug discovery. As a consumer, it takes the R&D firm's output and uses it in the further development of a drug.

In early-stage collaborations of this nature, failure rates are high and the exact nature of future outcomes is difficult to anticipate. Thus, the incomplete contracting problems envisioned by Williamson (1975), Grossman and Hart (1986), and Hart and Moore (1990) are likely to be present. Given this fact, theories of incomplete contracting tell us that the allocation of ownership rights should play an important role in the provision of incentives. At the same time, the theoretical literature on relational contracting (Baker, Gibbons, and Murphy 1994, 2002; Baker, Gibbons, and Murphy 2004) and reputation (Diamond 1984; Klein and Leffler 1981) suggests that maintaining a reputation for being a certain type of agent may be important, especially when other solutions to incentive problems may be costly to implement. In our project, we employ a sampling procedure to hold the contracting problem relatively constant, which enables us to illuminate the ways in which variation in features of contracts can be attributed to differences in alliance ownership structures and R&D partner reputations.

3. Research Design, Sample Selection, and Variable Construction

Our sampling strategy is designed to generate a small sample of contracts in a homogeneous contracting space in which moral hazard problems and monitoring considerations are prevalent. A narrow, homogeneous contracting space facilitates a comparison of key contract features across alliances. Moreover, by focusing on an area in which contracting problems are likely to be considerable,

³ Alliances are most prevalent in the preclinical testing phase. Roughly half of the alliance activity recorded by Recombinant Capital during 1990–98 occurred in the development phase alone. Sixty-five percent occurred before clinical trials.

the alliances in question should acutely reflect the key incentive problems that the client and partner face. Finally, a small sample allows us to glean as much detail as possible from each observation.

For these reasons, we focus on large, early-stage, genomics-related strategic alliances initiated between 1990 and 1998. As described in the preceding section, the alliances call for the R&D partner to identify, validate, and/or screen drug targets, which are then developed into marketable drugs in collaboration with the client. Almost all of the deals in our sample occur at the development and preclinical stages of research.

In a sense, the null hypothesis behind the sample design is that a relatively homogeneous contracting space will give rise to widely accepted contracting practices that will appear repeatedly in our data. With such a sample, we can be assured that variation in contracting terms comes not from variation in the underlying contracting environment but from different solutions to a common contracting problem, which in turn may reflect underlying differences in firm characteristics. Of course, we will witness a high degree of repetition if common problems arise that are dealt with in much the same way. When this occurs, we can conclude that these features of contracts are robust to differences in the characteristics of the firms in question.

3.1. Sample Construction

The data we use for this study come from a database assembled and maintained by Recombinant Capital, a biotechnology industry analysis firm that provides access to a wide range of contract-related information based on data culled from public filings, news releases, and presentations at industry conferences. Recombinant Capital tracks interfirm collaborations in human medicine, agreements involving universities, and collaborations in related fields such as agricultural technology and veterinary medicine. They maintain a searchable, master alliance database with links to alliance contracts and a database of financing histories for selected firms. We make use of both files.

Our sample was created by performing a keyword search on the alliance database to identify genomics-related deals. In addition, we restrict attention to deals that were already analyzed by Recombinant Capital, meaning that Recombinant Capital employees had synthesized the SEC filings, news announcements, and evidence from industry meetings and the trade press into a common document format. This format is standard across observations and includes sections for the description of the alliance activity, the licensing terms, manufacturing provisions, oversight, and equity participation. Each section contains a standardized number of text fields. By selecting deals that have been analyzed by Recombinant Capital, we skew the sample toward large deals that were perceived to be important by industry participants. This is in keeping with our sampling objective.

These screens yield 218 deals from the larger set of 3,186 total deals of all

Table 1
Sample Selection

Sample	Number of Contracts	Licensing Deals	Involved Equity	Deal Size
Total alliances (1990–98)	3,186	1,790	607	7.62
Final sample	125	113	81	41.46
<i>p</i> -Value (total – final)		>.0001	>.0001	>.0001

Note. Sample characteristics are presented for the 125 deals selected from the total sample of 3,186 alliances on the Recombinant Capital database between 1990 and 1998. Pharmaceutical firms are clients, and biotechnology research and development firms are partners. Deal size is the average amount of total contingent funding that could be paid to the biotechnology firm, in millions of dollars. Licensing deals are ones that involve licensing agreements as part of the initial contract. Involved equity indicates whether the client took an equity stake in the partner. The reported *p*-values test equality of sample fractions assuming unequal variances.

types listed on the Recombinant Capital database for this time period. On the basis of subjective evaluation, we further exclude 66 deals that are essentially standard licensing agreements for preexisting products or services (for instance, granting access to a proprietary database), since these activities fall outside the scope of our sample description. In addition, we exclude 26 additional contracts because they concern drugs in phase II or phase III clinical trials. Our final sample contains 125 contracts.

Table 1 describes the sample selection process. Our sample of 125 contracts differs significantly along several dimensions from the average contract listed on the Recombinant Capital database. Of the total sample of 3,186 deals, 1790 (56 percent) involved licensing agreements. By comparison, 113 of 125 contracts (90 percent) in our final sample involve licensing agreements.⁴ That such a large fraction of deals contain licensing provisions may reflect the relatively strong bargaining power of the firms in our sample. A number of the R&D firms in our sample were leading firms using a new technology that at the time was expected to revolutionize the drug development process. In many of the early biotechnology alliances, the R&D partner was unable to negotiate for a royalty stream based on product sales. As a result, licensing deals become more common in the later period spanned by the Recombinant Capital database, when we draw our sample.

Table 2 also describes the sample firms in greater detail. A total of 68 pharmaceutical clients and 60 R&D partner firms appear in the sample, which means that many firms appear more than once. We use Recombinant Capital, the Center for Research in Securities Prices, the SEC Edgar database, and the BioSpace online directory to verify the ownership status of the 60 partner firms. Seventeen

⁴ Licensing agreements allow the biotech firm to share in the revenues of pharmaceutical products that arise from the research they conduct as part of the agreement. Sometimes this revenue sharing takes the form of a proportional share of revenues; other times geographical segmentation is used to allocate profits. For instance, the licensing agreement may state that firm A has rights to market a drug in North America, while firm B has rights in all other countries. Some agreements will also be coded as licensing agreements if they involve the pharmaceutical licensing technology from the R&D firm.

Table 2
Firm Characteristics

	Pre-IPO	Post-IPO	Total
Distinct pharmaceutical client firms:	. . .	68	68
Distinct biotechnology partner firms:	43 [†]	33 ^{††}	60
Later went public out of sample [†]	19		
Appear as both in sample ^{††}	16		

Note. IPO = initial public offering.

firms appear in contracts only as publicly held firms, while an additional 16 appear as both private and public firms at different point in the sample period. Of the 27 remaining firms that appear only as privately held firms in our sample, 19 later went public but are not in our sample, having initiated an alliance while publicly traded. Eight firms were privately held, had been acquired, or were no longer in existence as of December 31, 2001.

Table 3 describes some key contract characteristics. The client purchases an equity stake in the R&D partner in 65 percent of the deals in our sample; this is significantly higher than the 19 percent (607 of 3,186) equity participation rate in the total alliance sample.⁵ This occurs in part because we have oversampled early-stage deals. Also, by focusing on a new technology we naturally oversample young private firms. Pisano (1989) and Robinson and Stuart (2007) show that equity is more common in early-stage, research-intensive alliance transactions. Given the high degree of uncertainty surrounding research outcomes and the attendant difficulty in specifying future contingencies, the use of equity here is consistent with the Grossman/Hart/Moore interpretation of ownership as a device for allocating decision rights when contracts are incomplete.

Finally, the mean deal size in our sample is roughly 6 times larger for our sample than for the Recombinant Capital database as a whole. This difference is highly significant.

3.2. Variables

To facilitate a quantitative analysis of the 125 contracts in our sample, we create a number of variables based on a close reading of each contract. In keeping with the objectives of our sampling strategy, we group variables into three categories: contract based, ownership based, and experience based.

3.2.1. Contract-Based Variables

First, we construct a set of variables that are designed to summarize key features of the alliance contract. These variables reflect concerns about monitoring, con-

⁵ A recent paper by Allen and Phillips (2000) shows that in most alliances one party purchases equity in the other but not vice versa. This is true of biotechnology alliances in general (Lerner and Merger 1998; Lerner, Shane, and Tsai 2003) and of our sample in particular.

Table 3
Deal Characteristics

	Total	Biotech Firm Is		Deal Size
		Pre-IPO	Post-IPO	
Total	125	69	56	41.46
Equity backed ^a	81	53	28	48.2
Licensing	113	60	53	41.84
Up-front payments	74	39	35	41.82

Note. IPO = initial public offering.

^a Indicates significant difference across groups ($p = .0058$).

tract incompleteness, bargaining power, and the allocation of rents arising from the activities in question.

There are three types of contract-based variables. First, we collect as much financial information about the deal as possible. This includes whether any up-front payments occurred (Up-front Dummy), the size of these up-front payments (Up-front Amount), and the total value of all contingent payments that could occur over the life of the contract (Deal Size). Ultimately, however, our financial measures are incomplete because we do not observe royalty rates and do not have any way of weighting expected future payments by the probability that they will occur.

Second, we record specifics of the contract concerned with the timing of various actions. We record the stage of research at the initiation of the project (Project Stage), the expected length of the collaboration (Research Term), a dummy for whether future investments are contingent on achieving milestones (Staged Investment), and a dummy for whether the contract explicitly states at the outset that the contract may be extended (Extendable).⁶

Third, we record contract details associated with monitoring. Most contracts specify the creation of oversight committees and indicate how often they meet to monitor the progress of the research activity. We record the number of committee meetings per year (Meeting Frequency). We also record any employment conditions or key-man provisions, such as the number of full-time equivalent man-hours and grade level or skills of particular employees (Ph.D., specialized research discipline, or named individuals). We record dummies for whether these provisions occur.

Finally, the SEC grants confidentiality to some business-sensitive provisions in alliance contracts. When this occurs, the original language is redacted and replaced with CON. We record the number of times this occurs in each document (Confidential).

⁶ There are 107 discovery-stage research deals, 11 lead-molecule stage deals, seven preclinical deals, and four deals begun at phase I clinical trials.

3.2.2. Ownership-Based Variables

To study the importance of equity as a mechanism for allocating control and aligning incentives, we construct a number of variables to describe the presence and structure of equity. We record whether an equity stake was purchased, the dollar value of this stake, and, when available, the fraction of the partner firm's total equity that this equity stake represents. We also record whether the equity is common or convertible preferred. In addition, we record a dummy for whether board seats are granted in conjunction with the equity stake. Finally, many contracts stipulate that other forms of financing are tied to the equity stake. We record whether the client grants loans to the partner in conjunction with the equity and whether the contract stipulates that additional equity is purchased in conjunction with the (privately held) partner's IPO.

3.2.3. Experience-Based Variables

We create a number of variables designed to measure the extent of the partner firm's prior alliance activity and prior funding relationships. There are several motivations for studying how past experience influences the features of the current contract.

First, a wealth of prior experience may indicate that the partner has many ongoing projects. If this is the case, the client may be concerned that the partner will divert resources across projects (a form of moral hazard or multitasking as in Holmström and Milgrom [1991]) and thus may require stronger contract-based controls or more ownership. Alternatively, prior alliances or prior funding may lower monitoring costs for the client involved in the current transaction by allowing it to free-ride off monitoring that is already taking place. Also, extensive prior experience may strengthen the partner firm's bargaining position in negotiations with the client. Both of these explanations predict that past experience is associated with less explicitly stringent contracts and/or less ownership-based control.

To allow for these possibilities, we construct several measures of past experience using both Recombinant Capital's data on financing histories as well as their complete alliance database. We record the age of the R&D partner, the number of prior deals they have executed, the fraction owned by VC (for privately held firms), and firm value. For private firms, this is the valuation in the last VC round. For publicly traded firms, this is the market capitalization 1 month prior to the contract date.

Strategic alliances may also rely on implicit contracts that are enforced through relational mechanisms. Because partner firms with many past experiences have many potential contracting partners (Gulati 1995), the cost of reputational sanctions increases with the quality of the reputation. Thus, a final motivation for studying prior experience is that through their past actions, firms may acquire relational capital that affects the trade-offs between contract-based and ownership-based provisions. The prediction here is that implicit contracts will provide

relatively stronger compliance incentives for firms with a wealth of prior experience, and thus alliances with such firms will involve less equity-based and contract-based control.

To contrast this explanation with the others outlined above, we also use a measure of past deal activity, known in the social networks literature as centrality (Bonacich 1987). Centrality is a measure of reputational prominence in a network. It is computed by weighting each tie that a firm has to another network member by the influence that partner has in the network. This recursive measure captures the idea that a past alliance with an influential client—which in this case is a client with access to many future counterparties—may be more valuable for reputation formation than an alliance with a relatively unknown client.

To compute the centrality measure, we take the entire Recombinant Capital alliance database and create a sequence of $n \times n$ matrices of interfirm alliance transactions, $\mathbf{X}_t$, in which x_{ij} is unity if an alliance has occurred between firms i and j in the 5 years prior to year t and zero otherwise. A convenient property of this matrix is that the ij th element of $\mathbf{X}_t^n$ measures the number of n -step paths between firms i and j —that is, the number of connections between firm i and j that pass through exactly $n - 1$ other parties. For example, if firm A has an alliance with firm B, which in turn has an alliance with firm C, then there exists a two-step path between A and C.

Following Bonacich (1987) we define centrality as

$$\text{Centrality}(\alpha, \beta) = \alpha \sum_{k=0}^{\infty} \beta^k \mathbf{X}_t^{k-1} \mathbf{1}, \quad (1)$$

where α is a scaling factor, $\mathbf{1}$ is a column vector of ones, and $\beta > 0$ is a discount factor that places less weight on more distant network ties.⁷ The variable α is determined by solving the following equation:

$$\alpha = \sqrt{\frac{n}{\sum c^2(\alpha, \beta)}}, \quad (2)$$

where n is the number of firms in the network. Doing this ensures that the squared length of $c(\alpha, \beta)$ equals the number of nodes in the network. This means that $c(\alpha, \beta)$ scores measured at different points in time, that is, when the number of firms in the network differs, will not change arbitrarily with the size of the network.

Firms with ties to more influential partners have higher centrality scores. Centrality is positively correlated with the number of past deals but will vary according to whether the partners in past deals have themselves entered into

⁷ The more general expression for centrality is $c(\alpha, \beta) = \alpha(\mathbf{I} - \beta\mathbf{X}_t)^{-1}\mathbf{X}_t\mathbf{1}$. Equation (1) is a special case that holds when $\beta > 0$. See Bonacich (1987) for more details. Following prior work in this area (Robinson and Stuart 2007; Sorenson and Stuart 2001; Podolny 1993), we set β equal to 3/4 of the reciprocal of the largest eigenvalue of the matrix $\mathbf{X}$, thus assigning more power to agents who are linked to those with high centrality scores.

Table 4
Cycle of Equity Participation

	Partner Is Privately Held (<i>n</i> = 69 Contracts)			Partner Is Publicly Held (<i>n</i> = 54 Contracts)	
	No Equity (<i>n</i> = 17)	Convertible Preferred (<i>n</i> = 40)	Common Equity (<i>n</i> = 12)	Common Equity (<i>n</i> = 27)	No Equity (<i>n</i> = 27)
Deal size***	[20.9]***	[45.5]	[37.6]	[[53.2]]*	[[34.4]]
Staged?	15	39	12	24	25
Extendable? ^{††}	11	33	10	15	18
Up-front dummy	10	21	6	17	18
Up-front amount	[3.82]*	[1.78]	[2.33]	3.20	3.12
Firm age ^{†††,***}	[3.47]	[3.84]	[5.00]*	[[5.76]]	[[7.70]]**
Prior deals ^{†††}	3.06	3.39	4.64	10.13	8.86
Centrality ^{†††}	.29	.33	.69	1.19	.96
Firm value ^{†††}	58.96	61.03	90.12	205.95	179.33
Venture capital ownership ^{†††}	[.70]*	[.54]	[.59]	. . .	. . .
Equity amount ^{†††} (\$)	. . .	6.32	5.46	10.07	. . .
Equity stake ^{††} (%)	. . .	[.13]***	[.09]	[.06]	. . .
Initial public offering tie-in	. . .	12	6	. . .	. . .
Loan tie-in	. . .	[2]	[3]**	4	. . .
Board seats ^{††}	. . .	7	3	2	. . .

Note. The use of equity at various stages of the target firm's life is reported. Two contracts involving convertible preferred equity in publicly traded target firms have been omitted. Symbols next to bracketed numbers in the body of the table indicate that the number in question is significantly different than the other bracketed categories in that row.

[†] (*) Statistically significant differences in group means by public versus private (equity versus no equity) at the 10% level.

^{††} (**) Statistically significant differences in group means by public versus private (equity versus no equity) at the 5% level.

^{†††} (***) Statistically significant differences in group means by public versus private (equity versus no equity) at the 1% level.

many alliances. Thus, we associate higher centrality scores with better reputations. In the context of relational contracting, a stronger R&D partner reputation implies that the client has greater faith that relational contracts will bind, since that partner has more to lose by violating implicit contracts. Relational contracting arguments lead us to expect that R&D partner centrality is associated with less contract- and ownership-based control.

4. Alliance Funding and the Cycle of Equity Financing

Table 3 indicates that the fraction of deals involving equity is significantly higher among privately held firms than among publicly traded firms in our sample. Table 4 explores the role of equity financing in greater detail, presenting statistical comparisons by equity type, deal type, and firm type. Throughout the table, asterisks next to variable names in the far-left column indicate significant differences in variable means by equity versus not equity. Daggers indicate significant differences in means by public versus private firms. Asterisks appearing

in the cells of the table denote statistically significant differences between sets of bracketed numbers.

Table 4 shows that the type of equity depends greatly on the ownership status of the partner firm. Among privately held firms, 40 of the 52 equity agreements are structured as convertible preferred securities. In contrast, all but two equity agreements with publicly traded firms were structured as common equity.⁸

4.1. Equity and Contract Characteristics

The upper portion of Table 4 indicates that the use of equity is significantly correlated with a number of contract- or activity-related characteristics. First, the total deal size is significantly larger for contracts involving equity, regardless of whether the partner is public or private. There are also significant differences in deal size within ownership categories. Among privately held firms, deals without equity are significantly smaller than deals with either convertible or common equity. Likewise, among publicly traded firms, the mean deal size is \$53.2 million for contracts with equity but only \$34.4 million for contracts without equity. This difference is significant at the 10 percent level.

Like VC investments, the funding provided in the deals in our sample is almost always staged. The use of sequential investment is robust to differences in firm characteristics: all but three deals with private firms have explicit staging provisions, and all but five deals with public firms are staged. This staging allows the client to capture the option value associated with expansion or early abandonment. At the same time, it introduces monitoring and incentive problems associated with efficient allocation of decision-making rights. We discuss these issues in detail in Section 5.

4.2. Equity and Measures of Experience

The middle portion of Table 4 relates the nature of equity stakes in alliances to measures of the partner firm's past experience and reputation. The data indicate that alliances follow a cycle of equity participation corresponding to the partner firm's age. This can be seen by comparing the R&D partner firm age across equity/ownership status categories. The youngest private firms receive no equity backing. Deals involving convertible equity occur at a later stage in the firm's life. Later still, common equity prevails—privately held R&D partners in deals with common equity are significantly older than firms receiving convertible equity or no equity. Deals with firms that have recently gone public involve common equity stake, but deals with the oldest publicly traded firms do not. Publicly held firms involved in deals without equity are significantly older than publicly held firms in deals with common equity.

⁸ Two alliances involve convertible preferred equity in publicly traded companies. None of the variables reported in Table 4 is significantly different for these contracts than for contracts involving common equity in publicly traded firms. For clarity, we omit these two deals from Table 4. They are included in all other tables, but omitting them has no effect on any results in the paper.

Public and private firms differ in experience as well as age. Publicly held firms have been involved in significantly more past alliances than private firms have. However, it is not true in our sample that public firms are less likely to receive equity if they have engaged in more past deals. If anything, firms in common equity deals have slightly more active past alliance histories than firms in deals with no equity. As the centrality measure shows, assigning more weight to past deals with more influential clients does not affect this pattern.

Table 4 reports differences in valuation characteristics based on ownership status and type of equity. Publicly traded firms have higher market capitalizations than private firms. For private R&D partners, the fraction of shares owned by VC is significantly higher for firms in deals with no equity.

Taken together, these results suggest an interesting interplay between strategic alliance funding and VC funding. When we consider that VC ownership shares are highest for the youngest firms and that these firms receive smaller deals with no equity stakes, it appears that strategic alliances act as a form of late-stage VC. This characterization is further supported by the tendency for alliances to involve common equity as firms age, since common equity typically has fewer control provisions attached to it than preferred equity.

4.3. Staged Equity and Other Funding Provisions

Table 4 describes the terms of the equity stakes in greater detail. Although the dollar value of the equity stake is statistically larger in transactions with publicly traded firms, the fraction of the partner firm's equity purchased in an alliance is larger in deals with private firms. This is especially true when convertible preferred equity is involved; the average stake is 13 percent with convertible equity, which is significantly larger than the size of the average common equity stake in public or private firms.

In 18 of the 52 contracts involving equity stakes with privately held firms, the contract allows for or requires the client to increase its initial equity with additional equity purchased during the partner's IPO. For example, in the alliance between Bristol-Myers Squibb (BMS) and Cadus, BMS purchased a total of \$20 million of Cadus equity in three separate transactions. The first transaction involved \$12.5 million of class B convertible preferred stock. The second was for \$5 million and occurred as a result of Cadus achieving a research milestone. Finally, at Cadus's IPO in July 1996, BMS converted its B shares into 1.607 million common shares and purchased an additional \$2.5 million worth of common shares in the IPO. This suggests that alliances play a role in the book-building process leading up to an IPO or more generally in signaling the quality of the biotechnology R&D firm to financial markets.

Roughly 12 percent of the equity agreements in our sample also provide debt financing to the partner. These agreements are typically structured as equity buy-back agreements, wherein the R&D partner borrows money from the client, securing the loan with equity, which is returned when the debt is repaid. As

Table 4 indicates, seven of the nine loan provisions occur in agreements involving common equity. Comparing common equity to convertible preferred equity, we see that for privately held firms, the fraction of common equity deals involving loans (25 percent) is significantly higher than the fraction associated with convertible preferred (5 percent), reflecting the structure of convertible preferred securities. Similarly, Kaplan and Strömberg (2003) report that many VC equity stakes blend various types of straight debt and equity to form synthetic convertible securities.

In addition to these rights, many contracts contain provisions designed to limit the eventual control that can arise through the use of equity. Many contracts place limits on the number of shares that can be transferred or sold in any one year or allow the client to maintain its pro rata share ownership in the partner. Likewise, many equity agreements place limits on the maximum ownership percentage the client can acquire. As is the case with VC agreements, piggyback rights and demand registration rights are common ancillary covenants in equity agreements.⁹

4.4. *The Determinants of Up-Front Funding*

Finally, returning to the top portion of Table 4, we see that many agreements also involve up-front payments from the client to the partner. Given that up-front payments occur at the initiation of the contract and thus are not subject to performance milestones or subsequent renegotiation, R&D partner firms would presumably prefer larger up-front payments, holding all else constant. Likewise, the client firm would presumably like to minimize up-front transfers, *ceteris paribus*.¹⁰ This raises questions as to how the presence and magnitude of up-front payments to the R&D partner reflect its relative bargaining power. We examine these issues in this section.

Table 5 addresses these questions with regressions of up-front payments on various partner and deal characteristics. The first three columns model the probability that a deal contains an up-front payment to the R&D partner firm. In column 1, the independent variables are the total deal size, the presence of equity in the deal, the stage of the research involved (that is, whether it is discovery stage, lead-molecule, etc.), and R&D partner centrality. This regression shows that later stage projects are significantly more likely to include up-front payments to the R&D partner firm. Controlling for project stage, the deal size and the presence of equity are insignificant. Columns 2 and 3 include additional controls for the age of the partner firm and whether it is public or private. From these regressions we see that private firms are more likely to receive up-front payments, all else being equal.

⁹ Demand rights allow the holder to force the other firm to register its stock for sale; piggyback rights allow the holder to include its shares in any registration initiated by the other firm.

¹⁰ Of course, *ceteris paribus* is a critical caveat here, as firms invariably face a shadow cost of additional up-front funding in terms of more severe terms elsewhere in the contract. Indeed, up-front payments may be Pareto-improving for cash-constrained R&D partners.

Table 5
Determinants of Up-Front Payments

	(1)	(2)	(3)	(4)	(5)	(6)
Deal size	-.001 (.37)	-.001 (.37)	-.002 (.32)	-.002 (.89)	-.001 (.95)	-.000 (.99)
Equity (0/1)	-.128 (.23)	-.163 (.15)	-.143 (.21)	-1.353 (.18)	-1.858 ⁺ (.07)	-1.364 (.15)
Project stage	.214* (.02)	.256** (.01)	.253** (.01)	2.428** (.00)	3.007** (.00)	2.906** (.00)
Centrality	.144 ⁺ (.08)	.211* (.04)	.207 ⁺ (.05)	1.380 ⁺ (.07)	2.263* (.01)	2.098* (.01)
Public (0/1)		-.156 (.24)	-.144 (.28)		-2.360 ⁺ (.06)	-1.907 ⁺ (.10)
Firm age			-.002 (.90)			-.020 (.88)
Constant				-3.720** (.01)	-3.731** (.01)	-3.800** (.01)
N	103	103	101	106	106	103
Pseudo-R ²	.07	.08	.08	.04	.05	.06

Note. Up-front payments are linked to ownership, deal characteristics, and partner firm reputation. Columns 1–3 model the probability that a contract contains up-front payments to the research and development partner. Coefficients are expressed in percent changes in the probability of up-front payment associated with the independent variable. Columns 4–6 present Tobit regressions of the up-front payment amount, in millions of dollars, on the same set of independent variables. Up-front amounts are set to zero when no up-front payment occurred. Robust *p*-values appear in parentheses.

⁺ Significant at the 10% level.

* Significant at the 5% level.

** Significant at the 1% level.

Columns 1, 2, and 3 also demonstrate that the centrality of the R&D partner is positively related to the probability that it receives up-front payments. Without controlling for the firm age or public status, centrality is marginally significant, with a *p*-value of approximately 10 percent. But when we control for whether the R&D partner is public, centrality is statistically significant. This also holds controlling for the age of the firm.

Columns 4, 5, and 6 show that the centrality of the partner firm is also positively related to the magnitude of the up-front payment. These columns present Tobit regressions of the size of the up-front payment, in millions of dollars, on the same set of independent variables described above. From column 5 we see that equity deals contain significantly smaller up-front payments to R&D partners and that publicly traded R&D partners receive less up-front funding.¹¹ Irrespective of these controls, we see that the size of the up-front payment loads positively and significantly on R&D partner centrality.

One interpretation of these results is that R&D partner firms with many past alliances are in a stronger bargaining position because they can credibly generate competition among potential clients, thus raising the probability and size of up-front concessions. The positive effect of centrality on up-front funding is also consistent with the interpretation of centrality as a proxy for the R&D partners reputation. Because up-front payments are noncontingent and thus eligible for misuse, clients are presumably less reluctant to provide them in deals with R&D partners that have better reputations. Since clients inherently have less control

¹¹ The fact that publicly traded R&D partners receive lower up-front funding amounts suggests that up-front funding may be used to alleviate cash constraints in the R&D partner firm. If this is the case, then presumably both parties may strictly prefer up-front funding to alternative funding arrangements. We are grateful to the referee for pointing this out.

over the use of up-front payments than equity or research milestones, the findings in this section are consistent with the results of Robinson and Stuart (2007), who show in a large sample of similar transactions that deals involving partner firms with better reputations tend to be larger and contain fewer control provisions. Robinson and Stuart (2007) cannot, however, distinguish between up-front payments and pledged future payments in their large sample. Thus, the results here sharpen the previous findings on the importance of partner reputation in determining the allocation of control in alliances.

4.5. *Equity, Board Seats, and Control Rights*

This subsection explores how, whether, and to what extent the allocation of equity affects the allocation of control in strategic alliance agreements. The description of equity participation presented thus far shows that strategic alliances bear a strong resemblance to VC agreements. This comparison becomes more nuanced, however, when we examine how control rights and, in particular, board seats are allocated in these agreements.

Table 4 shows that while board seats sometimes coincide with equity stakes, they occur less often than we would expect to observe based on the frequency of board seats in VC agreements. In particular, of the equity transactions, 12 of the 81 (15 percent) include board representation for the investor.

A closer examination of these 12 deals, however, reveals a tight link between the allocation of equity and the allocation of control. Ten of these deals involving board seats were with pre-IPO firms; 11 of the 12 deals were part of research collaborations that were at discovery stage—research that is in the earliest stages and therefore with the greatest scope for contractual incompleteness. These two facts alone suggest that board seats are definitely used to allocate control rights to the client firm.

An excerpt from the Ciba-Geigy/Chiron alliance initiated in November 1994 reveals how the number of board seats can vary explicitly with equity size:

After the Closing, the Board of Directors of Chiron will be comprised of 11 directors. Initially the Board of Directors will include three Managing Directors (names listed), five Independent Directors (names listed) and three directors designated by Ciba (“Investor Directors”), one of whom will be (name listed).

If Ciba’s percentage interest for any period is less than 30% but at least 20%, during that period Ciba will instead have the right to designate two Investor Directors, and if Ciba’s percentage interest is less than 20% for any period, during that period Ciba will instead have the right to designate for nomination only one Investor Director.

From this excerpt it is clear that not only is there variation across deals in how board seats are allocated based on the amount of equity, but there is also within-contract variation based on how the equity stake grows or shrinks.

To get a sense of variation across deals, as opposed to within deals, Table 6 summarizes the relation between equity size and board seats among the 81 deals

Table 6
Allocating Control Rights through Equity Stakes

Number of Board Seats	Contracts	Mean Equity Stake (\$ Millions)	Mean Firm Size (\$ Millions)
0	69	6.83	116.89
1	11	11.31	106.44
2	1	20	79.27

Note. The firm value figure is either the market value of equity if the target is publicly traded or the value at the last venture capital (VC) round if it is private. That is, if the VC firm paid \$ X for a γ percent stake in the firm, then the value recorded is X/γ .

in that sample that involved equity stakes. The equity stakes associated with no board seats are generally small in magnitude and are associated with larger firm values. This implies that the ratio of equity to overall firm value is rather low—about 5 percent. Equity stakes associated with a single board seat are about twice as large on average and occur in smaller firms so that the ratio of equity stake to firm value for deals with a board seat is about 10 percent. And in the lone deal that involved two board seats in the sample of 125 contracts, the client firm took a 25 percent equity stake. This certainly suggests that the control rights afforded to the client firm are an increasing function of fraction of equity to total target firm size.¹²

Other terms from individual alliance contracts shed further light on the question of control. Consider this excerpt from one of the deals in our sample, the American Home Products/Affymax alliance: “If AHP should own voting securities of Affymax representing at least 15 percent of the outstanding common shares determined on a fully diluted basis, Affymax shall nominate as a member of management’s slate of managing directors one person designated by AHP. Such right shall terminate, and the AHP nominee shall agree in writing that such nominee shall resign from Affymax’s Managing Board of Directors, at such time as AHP owns less than 10% of the outstanding common shares determined on a fully diluted basis.” This part echoes the discussion above. The more interesting part comes from the following excerpt: “AHP agrees that while the Collaboration is in effect it will not directly or indirectly acquire Affymax securities above 15% of the outstanding shares of Affymax determined on a fully diluted basis (with any potential purchases under the First or Second Extensions included in such calculations but excluding the effect of any exercise by Affymax of its option).” This excerpt suggests that Affymax is concerned about AHP acquiring too much control by increasing its equity stake. Thus, the terms of specific contracts suggest that control rights are increasing in the size of the

¹² Further evidence that equity is used to address moral hazard considerations can be found by relating the probability of a deal containing an equity stake to its size as a fraction of the partner firm’s total value. Moral hazard concerns would suggest that equity is more likely when the deal is a small fraction of the partner’s total value. In unreported tables, we find evidence along these lines.

equity stake and that contracting parties are concerned about the effects of increasing equity stakes on those control rights.

Therefore, while there is clear evidence that parties use equity ownership to allocate control rights, board seats are relatively uncommon. In contrast, Kaplan and Strömberg (2003) find that VCs almost always receive board seats and in fact find that VCs often receive a majority of board seats, especially in the early stages of a firm's life. The disparity between equity stakes and board rights relative to what we would expect from VC contracts raises the question of what other mechanisms are used to monitor research activity.

While clients infrequently receive firm-level control stakes in their alliance partners, the next section shows that they often hold decision-making authority in the specific alliance project that the partner conducts with them. This illustrates a key difference between VC and alliance contracts: a VC invests in a firm, whereas in an alliance, the client invests in a project inside the partner firm. Given that some R&D partners have engaged in many past deals and that virtually all R&D partners operate multiple projects concurrently, this raises the question of how alliance contracts deal with moral hazard problems, multitasking concerns, or other incentive conflicts that arise when the partner has the opportunity to divert resources from one activity to another. We explore these issues in detail below.

5. Project Management, Oversight, and Control

One of the most common features of alliance contracts is the reliance on project-level monitoring based on research committees, as opposed to board-level control. Table 7 indicates that 95 percent of contracts in our data (119 of 125) explicitly create committees that periodically meet to monitor the progress of the collaboration. Of these 119 contracts, 17 also establish oversight committees, which are concerned with the long-term strategic direction of the collaboration rather than with the day-to-day operations of the project. It is standard for the client and partner to be equally represented in these committees. Majority or unanimity is almost always required to act on a decision, but contracts vary as to whether the client receives a tie-breaking vote when deadlocks arise. The alliance contract typically establishes a chain of command that dispute resolution must follow.

5.1. *Observability and Verifiability*

Interestingly, many provisions that reflect the distinction between project- and firm-level control are based on conditions that are costly, if not impossible, to verify. For example, 20 contracts contain provisions requiring that a partner apply the same level of effort to the alliance activity as it does to its other projects or that a client pursue all commercially viable options to develop an in-licensed molecule, treating it as it would one of its own, internally developed molecules.

Table 7
Research Management and Oversight Provisions

	Total Contracts	Employment					Oversight Committees				
		Any	FTEs	Pay Grade	Persons	Board Seats	Research	Oversight	Majority	Unanimity	
Total	125	64	55	12	16	12	119	17	41	35	
Pre-IPO	69	37	34	9	11	10	65	9	23	19	
Post-IPO	56	24	21	3	5	2	54	8	18	16	
<i>p</i> -Value(diff)		.23	.19	.13	.23	.03	.56	.84	.89	.90	
Equity	81	42	38	9	13	12	77	10	30	22	
Nonequity	44	19	17	3	3	0	42	7	11	13	
<i>p</i> -Value(diff)		.36	.38	.41	.10	.01	.92	.58	.17	.78	
Discovery	106	51	47	9	14	11	100	12	35	32	
Lead molecule	10	7	6	2	1	0	10	3	4	0	
Preclinical	7	2	2	0	0	1	7	1	1	2	
Phase 1	2	1	0	1	1	0	2	1	1	1	

Note. FTEs is a dummy for whether the client specifies the number of man-hours the partner is to spend on research; Pay Grade is a dummy for whether these man-hours are to be performed by scientists with specific training or background (for example, Ph.D., biochemists). Persons is a dummy for whether a contract is contingent on the performance of a specific, named individual employed at the research and development firm. Board Seats is a dummy for whether the client receives a seat on the partner firm's board of directors. Research committees are project-level committees that manage routine details of the alliance. Oversight committees oversee the broader strategic direction of the alliance activity. Majority and Unanimity are dummies for whether a simple majority or a unanimous ruling is required when committee decisions are voted on. IPO = initial public offering.

Table 8
Determinants of Project-Level and Firm-Level Oversight

	Pr(Employment Provisions)			Pr(Board Seats)		
	(1)	(2)	(3)	(4)	(5)	(6)
Firm age	.010 (.56)	.009 (.61)	.013 (.43)	-.009 (.56)	-.008 (.58)	.002 (.68)
Public (0/1)	-.014 (.90)	-.104 (.41)	-.067 (.61)	-.173* (.02)	-.179* (.02)	-.073* (.01)
Centrality	-.197* (.03)	-.266** (.01)	-.280** (.01)	.052 (.47)	.051 (.47)	-.019 (.56)
Confidential		.012** (.00)	.012** (.00)		.001 (.70)	-.001 (.35)
Deal size			-.001 (.77)			.001** (.00)
Up front (0/1)			.071 (.54)			-.112* (.02)
Equity (0/1)			.164 (.20)			
N	106	106	101	71	71	68
Pseudo-R ²	.04	.19	.20	.08	.08	.48

Note. Regressions are presented that model the probability that the contract specifies employment provisions (columns 1–3) or allocates board seats to the client (columns 4–6; see Table 7). Up-front (0/1) and Equity (0/1) are the dummies for whether an up-front payment or equity payment occurred. Units are expressed as the percent change in the dependent variable associated with a unit change in the independent variable. Robust *p*-values appear in parentheses.

* Significant at the 5% level.

** Significant at the 1% level.

Thus, contracts display an awareness of moral hazard problems but not necessarily an explicit solution to them.

Similarly, Table 7 indicates that roughly 50 percent of the contracts (64 of 125) included in our data require the partner to allocate to the research project in question minimum levels of human capital. Of the 64 contracts that contain human capital provisions, 55 specify labor quantity: they fix the number of full-time equivalents (FTEs) that must be devoted to a research project. Twelve go further to provide quality restrictions: they require that persons with specific employment grades or education levels work on the project. For example, a contract might require that personnel be appropriately qualified in biochemistry or biology or that they hold Ph.D. degrees. In addition, 16 contracts specify that certain, named individuals must be employed strictly on a particular project, that they must not be allowed to work on other projects, and that renegotiation should occur if the individual becomes unable to work on the project.

As with the best-efforts provisions described above, the obvious question that arises here is how these provisions are verified. It is standard in the theory of incomplete contracts to assume that many actions are observable but not verifiable; verifiability then becomes the key basis for enforcing contracts. On the other hand, the literature on relational contracting opens the possibility that agents may write implicit contracts based on observable but unverifiable actions. Discussions with industry professionals suggest that there are no explicit mechanisms for monitoring labor allocation across projects. Similarly, it is difficult to conceive of mechanisms that allow a counterparty to verify that best efforts have been applied to a project. This opens the question of whether ownership or past experience is related to the use of seemingly unverifiable contract provisions.

Table 8 further explores the issues of verifiability and firm- versus project-

level control. The first three columns of Table 8 model the probability of a contract containing employment provisions as a function of contract-based, ownership-based, and experience-based variables. Columns 4–6 model the probability of a board seat conditional on the client purchasing equity.

The key determinants of whether a contract contains employment provisions are the centrality of the R&D partner and the number of confidential provisions in the contract. The loading on confidential provisions indicates that contracts making use of sensitive business information are more specific, even if the actions specified are costly to verify. The coefficient on centrality indicates that a unit increase in the reputation of the partner lowers the probability of employment provisions by 18–24 percent. This is consistent with a relational contracting explanation. Since the set of future business partners is highly correlated with the set of past transactors (Gulati 1995), it indicates that firms with stronger reputations in the alliance community can be trusted to perform according to the implied intentions of a less specific contract than would otherwise be required, presumably because the threat of lost future contracting opportunities is more salient for these firms (Robinson and Stuart 2007).

In contrast, centrality has no explanatory power in regressions that model the probability that an equity stake also includes a board seat. Instead, board seats are more common among larger projects with private firms. The fact that the up-front payment dummy is significantly negatively correlated with the probability of board seats suggests that partners who are able to bargain for larger up-front payments can also limit the amount of firm-level control they cede to the client.

6. Termination Provisions and Ownership of Abandoned Intellectual Property

The right to terminate a project is a key strategic consideration in many theories of financial contracting. Termination rights are central in Bolton and Scharfstein (1990) and Hart and Moore (1998), in which the outside financier's ability to shut down the entrepreneur's project at some intermediate stage (before unobservable cash flows arrive) reduces the entrepreneur's incentive to consume private benefits. In addition, Nöldeke and Schmidt (1995, 1998) study how the allocation of option rights can alleviate holdup problems when contracts are incomplete.

Not surprisingly, a key feature in almost all biotech strategic alliances is the allocation of the right to terminate the alliance. Table 9 provides evidence on the allocation of termination rights. These provisions either lock both parties into the agreement, provide generic escape clauses that do not specify future contingencies, or make termination contingent on future events or willingness to participate.

In only four out of 125 deals, the termination provisions state that either party may terminate only in the case of uncured breach. Thus, rarely does an

Table 9
How Alliances End: Details of Termination Rights in Strategic Alliances

Termination Provision	Both/ Either	Only R&D	Only Client	Examples
Uncured breach only	4	0	0	Either party may terminate by breach, by bankruptcy, by mutual agreement, or if the other party is acquired by any third party Shall be assignable only to an affiliate or a successor. In the event of an acquisition of [Target] by a pharmaceutical company which [Client], in its sole discretion, believes will adversely affect the Research Program, [Client] shall have the right to terminate the Research Program
Uncured breach or bankruptcy	100	0	0	
If change in control	11	0	38	
At will	4	0	16	May be terminated by [Client] any time after the 3rd anniversary of signing [M]ay be terminated by [R&D] if [Client] has not selected a [Target] for further evaluation prior to the expiration of the Research Period [Client] shall be entitled to terminate [if] [person], [person] or [person] is no longer obligated or able . . . to provide the same level of services as contemplated at the signing of this Agreement May terminate . . . if [person] or [person] ceases to be employed by [Target] . . . and if [Target] is unable to find such replacement who is reasonably satisfactory
At will after certain date	8	0	51	
Insufficient progress	9	1	20	
Change in key employees	0	0	8	

Note. Ownership reverts to research and development (R&D) includes all situations in which ownership reverts to the R&D, including cases in which ownership reverts with exceptions.

alliance contract lock both parties into a research agreement without some provision for future contingencies to shut down the deal. Instead, the R&D partner typically can only terminate on the client's uncured material breach, but the client has substantially stronger rights.

One contingency that commonly activates termination rights is the change in control of the counterparty. This right rests with the client far more often than with the R&D partner. In 38 contracts, the client has the right to terminate the project on a change in control, while this right is shared in only 11 cases. In our sample, the right to terminate due to change in control is never allocated solely to the partner firm. The example provided in Table 9 clarifies the motivation for such termination rights: if one of the client's competitors acquires the alliance partner, the client's competitive position could be jeopardized. The competitive position of a partner firm is less threatened by a change in control of the client.

The strength of client-side termination rights is reflected in Table 9 by the frequency of at-will, progress-related, and key-man termination provisions that are allocated to the client but not to the R&D partner firm. The right to terminate the project at will is granted to the client exclusively in 66 contracts; in 51 of these contracts the right to terminate at will begins after the collaboration reaches a certain age. Only 12 contracts allocate at-will rights jointly, and no contracts allocate them exclusively to the R&D partner.

Insufficient progress is a common reason for contract termination. Again, this right generally rests with the client (20 contracts). In nine contracts, the right is shared, but only one contract allocates the right solely to the partner firm. Table 9 includes an excerpt of the text of this provision, which indicates that the partner firm's right to terminate hinges on the client's failure to select a drug target for further development.

In eight contracts, the client secures the right to terminate the alliance if certain key personnel are no longer available to work on the project. (This is separate from the personnel stipulations described in Section 5.) This indicates the importance of human capital in pharmaceutical research. If the basis of the alliance is the client's desire to access key individuals at a partner firm, then this provision reflects a sensitivity to holdup problems or shirking that arise from the partner's ability to redirect key researchers toward other projects inside the firm. Thus, this contractual feature plays the same role as intermediate financing in security design models (see, for example, Hart and Moore 1994), in which the threat of liquidation counteracts the entrepreneur's incentive to withhold effort at an intermediate stage to bargain for a greater fraction of the surplus *ex post*. However, with only eight contracts containing these provisions, it is difficult to gauge whether this is perceived to be a widespread problem in biotechnology alliances.

To get a better sense of how termination rights are allocated, we group them into two categories. We call termination rights "severe" if they not only include uncured breach provisions but also allow the client to terminate at will, if in-

Table 10
Termination Rights and Firm Life Cycle

Termination	Privately Held			Publicly Held	
	None (%)	Convertible Preferred (%)	Common (%)	Common (%)	None (%)
Amicable (37 deals)	24	26	18	38	37
Severe (80 deals)	71	66	73	57	59

Note. Amicable termination occurs in deals that specify termination for uncured breach but do not go on to include client-side at-will, insufficient-progress, and key-man clauses. Severe clauses specify client-side at-will, insufficient progress, and key-man termination provisions.

sufficient progress is made, or if key-man provisions are violated. In contrast, we call termination rights “amicable” when they provide for termination only in the event of uncured breach. Amicable termination provisions appear in 37 contracts. Far more—80 contracts—contain severe termination provisions.

Table 10 breaks down the percentage of contracts containing amicable and severe termination provisions according to the same ownership status/equity categories that are used in Table 4. While severe provisions occur more often with privately held firms, this difference is not statistically significant.

To understand what contract-based, ownership-based, and experience-based measures are associated with severe termination provisions, Table 11 presents regressions that model the probability of severe provisions as a function of deal and firm characteristics. Longer projects are significantly more likely to involve severe termination provisions, as are projects involving compounds at later stages of development. Both results suggest that uncertainty is an important consideration. Since there is less uncertainty in later stage projects, the client can more easily distinguish failure to exert effort from bad luck, and thus termination can be wielded more efficiently. Similarly, longer projects have more scope for unanticipated contingencies to arise.

We also include in the regressions a dummy for whether the contract includes employment provisions, since employment provisions frequently require that the biotech firm take observable but not verifiable actions.¹³ Across each specification, we see that the inclusion of unverifiable provisions increases the probability that the client has severe termination rights. One possible reason why contracts may contain difficult-to-verify provisions is that they are inexpensive to include up front and provide scope for protecting the client’s reputation in the event that the contract is terminated prematurely. The prevalence of severe termination provisions in conjunction with provisions that are difficult to verify helps to remove the need to verify provisions that may be costly to verify.

The size of the equity stake is significantly negatively correlated with the severity of termination. This is further evidence that ownership-based control substitutes for contract-based control. In addition, it points to the fact that

¹³ We are grateful to the referee for suggesting this.

Table 11
Explaining the Use of Severe Termination Provisions

	(1)	(2)	(3)	(4)	(5)
Research term	.072 ⁺ (.10)	.079 ⁺ (.07)	.155** (.00)	.183** (.00)	.184** (.00)
Project stage	.180* (.02)	.170* (.03)	.162 ⁺ (.07)	.194* (.04)	.188 ⁺ (.05)
Employment provisions		.178* (.04)	.210* (.03)	.198* (.04)	.185 ⁺ (.06)
Deal size			.000 (.87)	-.000 (.88)	.000 (.97)
Equity amount			-.024** (.01)	-.027** (.00)	-.028** (.00)
Firm age				-.025 (.20)	-.020 (.33)
Public (0/1)				.006 (.95)	.029 (.83)
Target's centrality					-.063 (.55)
N	114	114	108	105	103
Pseudo-R ²	.05	.08	.15	.19	.19

Note. Probit regressions in which the dependent variable is a dummy for whether the contract uses severe termination provisions, as defined in Table 6. Coefficients are reported as percent changes in the dependent variable associated with a change in the independent variable, evaluated at the mean for each variable in question. Robust *p*-values are in parentheses.

⁺ Significant at the 10% level.

* Significant at the 5% level.

** Significant at the 1% level.

ownership-based control is more salient when the contracting environment is more ambiguous, since early-stage, equity-based contracts are significantly less likely to involve severe termination. Finally, it is worth noting that while the centrality measure comes in with the sign predicted by the relational contracting explanation, it is insignificant. Controlling for reputation-based considerations seems to have little impact on the allocation of termination rights.

Alliance contracts also address the issue of how the ownership of intellectual property is allocated after an alliance is terminated. In unreported tables, we show that contracts do not specify shared ownership on termination. This is consistent with Aghion and Bolton (1992), who show that co-ownership is typically suboptimal relative to contingent ownership, since co-ownership exacerbates holdup problems that generally lead to an undersupply of effort. Instead, most ex post ownership is contingent on the nature of termination. In 75 cases, ownership of residual intellectual property reverts to the R&D partner (with the exception of breach, change in ownership, or bankruptcy in some instances). Since termination provisions rest generally with the client, one would expect the contract to allocate ex post ownership to the partner firm to provide strong incentives to supply effort. Ownership reverts to the R&D partner significantly less often in longer term projects and significantly less often with older firms. Since longer term projects have greater scope for unforeseen contingencies to arise, the fact that ownership reverts to the R&D partner less often here reflects moral hazard considerations. Similarly, given that older firms have had, on average, more prior partners and potentially more ongoing projects, the fact that they are less likely to possess intellectual property in the event of termination potentially also reflects multitasking or moral hazard concerns.

7. Complexity, Ownership, and Relational Contracts

Contract specificity itself is another source of oversight that may complement or substitute for the firm-level and project-level control mechanisms described above. Finely detailed contracts leave less room for a counterparty to indulge in self-improving interpretations of vague provisions or gaps in the agreement. Vague contracts, on the other hand, rely on relational incentives, a common value system, or the allocation of ownership to ensure that the intentions of the agreement are carried out. The optimal contract balances *ex ante* contracting costs against potential *ex post* holdup (Crocker and Reynolds 1993). To explore the trade-off among contract complexity, ownership, and relational incentives, this section examines regressions explaining the information content of the alliance contract.

To measure the information content of the alliance agreement, we make use of the fact that the common document format used by Recombinant Capital imposes a certain uniformity across contract analyses that naturally gives rise to a measure of contract complexity. First, we place each contract analysis into an ASCII file. The standard document format implies that each ASCII file contains exactly 63 lines of varying width, depending on the amount of text used to describe that contract feature. Empty descriptors are coded "N/A," while lengthy descriptions extend horizontally in the ASCII file until all of the text in the description has been presented. For example, if a contract contained no provisions for the use of equity, then a number of lines of the contract analysis would be coded "N/A." These same lines in a contract with complicated buyback or warrant provisions would be lengthy. Similarly, if the nature of the alliance activity is difficult to describe and requires specifying a great many contingencies, then the contract analysis will contain lengthy descriptions in the fields devoted to the description of research.

Measuring the byte length of this file gives us a proxy for contract complexity. Longer ASCII files indicate that more future contingencies are identified in the contract or that each possible contingent action requires more complex language to describe. Interestingly, there is considerable variation in contract length: the mean ASCII file is 20 kilobytes, the median is 18 kilobytes, but the standard deviation is 10 kilobytes. Thus, even in the narrow contracting environment we have chosen to study, there is considerable variation in contract complexity.

Table 12 presents ordinary least squares regressions of contract complexity on firm and deal characteristics. The negative loading on project stage in Table 12 indicates that contracts are significantly longer in the earlier phases of the drug discovery process. Thus, contracts for discovery-stage research are longer than contracts for research on lead molecules or for preclinical research. This result contradicts the alternative interpretation for contract length, which is that longer contracts are associated with easier contracting environments, since in complex situations contractual language is simply inadequate to describe future contingencies and thus is not used at all.

Table 12
Information Content in Alliance Contracts

	(1)	(2)	(3)	(4)	(5)	(6)
Project stage	-1.329 (.15)	-1.742* (.04)	-1.997* (.05)	-2.624** (.00)	-3.225** (.01)	-3.051* (.02)
Meeting frequency	-.155 (.58)	.078 (.76)	-.272 (.35)	.041 (.87)	-.128 (.56)	-.159 (.48)
Board seat (0/1)	.364 (.87)	-1.471 (.48)	1.395 (.53)	-.358 (.87)	-.360 (.87)	-.171 (.94)
Deal size	.087* (.02)	.051* (.02)	.083* (.02)	.043* (.03)	.046* (.08)	.048* (.08)
Equity amount		.425** (.00)		.390** (.00)	.322* (.01)	.302* (.02)
Up-front amount		.680* (.09)		1.068** (.00)	.960** (.00)	.912** (.00)
Firm age			.354 (.32)	.063 (.84)	.233 (.41)	.293 (.32)
Public (0/1)			2.026 (.29)	1.151 (.53)	1.561 (.46)	-.370 (.91)
Firm value					.017* (.05)	.017* (.05)
Centrality					-1.641 (.26)	-3.386* (.03)
Centrality × Public						2.819 (.26)
Constant	19.802** (.00)	17.971** (.00)	18.434** (.00)	18.537** (.00)	17.918** (.00)	18.322** (.00)
N	106	105	104	103	89	89
R ²	.12	.25	.15	.28	.41	.42

Note. The dependent variable measures the length of the contract analysis in bytes. Meeting frequency records the number of times per year that the oversight committees set up to oversee the research projects meet. Equity amount and up-front amount measures the dollar value in millions of the equity stake and the size of the up-front payment from client to partner. Centrality × Public allows separate centrality estimates to be fit for public and private firms by interacting centrality with a publicly traded dummy. Robust *p*-values are reported in parentheses.

* Significant at the 10% level.

* Significant at the 5% level.

** Significant at the 1% level.

In general, contracts are longer in alliances in which more money is at stake. The size of the up-front payment, the equity stake, and the deal as a whole are all highly correlated with contract length. Comparing the point estimates on the size of the total deal, the equity purchase, and the up-front payment indicates that the greatest attention in contracts is paid to the most immediate types of funding. For example, in column 4, the point estimate on up-front payments is over twice the size of the point estimate on equity amount, which in turn is an order of magnitude larger than that for total deal size. These results suggest that clients write increasingly more elaborate contracts when the funding they provide is increasingly less under their control.

To explore how relational considerations vary with contract complexity, columns 5 and 6 of Table 12 also include the centrality of the R&D partner in the regressions. When centrality is included alone, it is negative, indicating that contracts are shorter when partner firms have stronger reputations. The loading is insignificant, however. To see how reputation effects vary with the ownership status of the partner firm, column 6 interacts centrality with the publicly traded dummy. From this we see that centrality is significantly negatively related to contract length for privately held firms but insignificant for public firms. The fact that having many influential partners is more important for private firms than for public ones suggests that the information conveyed through network connections (that is, the information available through one's reputation with past transactors) is most important for firms with the least amount of publicly available information.

Taken as a whole, Table 12 points to an intriguing set of interactions among ownership, complexity, and relational considerations. That more complex contracts are written for earlier stages of research reinforces the commonly held view that future contingencies are more difficult to anticipate in more research-intensive environments. The sensitivity of contract complexity to the ability to link payments to the R&D partner to its subsequent performance suggests that contract complexity substitutes for ownership. Yet larger equity stakes coincide with longer contracts even after controlling for the total size of the deal. Thus, ownership and contractual specificity also act as complements that appear to be used more as the contracting environment becomes increasingly ambiguous. This complementarity no doubt reflects the R&D partner's desire, in situations when it cedes greater equity control to the client, to delineate more carefully the circumstances under which that control can be exercised. Finally, the relation between contract complexity and reputation, especially for privately held firms, provides further evidence indicating that the ability to sanction an alliance partner, and thus damage its reputation among potential future counterparties, is a key mechanism for enforcing implicit contracts (Baker, Gibbons, and Murphy 2004; Robinson and Stuart 2007).

8. Toward an Explanatory Model of Contract Design

The preceding analysis is an intrinsically descriptive, partial equilibrium in the sense that it analyzes a single contract characteristic in isolation as a function of both exogenous characteristics and possibly other related contract terms. While this is a useful descriptive exercise, it fails to address the fact that many facets of the contract may be chosen simultaneously.

In this section, we attempt to explore the simultaneous choice of multiple contract characteristics as a function of observable firm and project characteristics. To do this, we use hierarchical cluster analysis to structure the 125 contracts in our sample according to their similarity to one another across a variety of dimensions. The features we consider are equity participation, up-front payment dummy, board seat dummy, research committee dummy, oversight committee dummy, IPO tie-in, loan tie-in, research tie-in, and whether the deal included amicable or probationary termination provisions.¹⁴ We chose these features on the basis of our preceding analysis.

The output from an hierarchical clustering algorithm can be expressed in terms of a tree that relates the dissimilarity of various contracts. The tree branches to reflect a group of observations that are distinct from observations along a different branch. We break our contracts into two groups and explore the average contract characteristics within each group. These groupings are presented in Table 13. Then in Table 14 we explore how exogenous firm and deal characteristics relate to the group distinctions.

8.1. Describing the Clusters

Table 13 reports the characteristics for 116 contracts that are captured by our cluster analysis. The cluster analysis is structured so that the 40 contracts in primary cluster 1 are more like one another than they are like any of the 76 contracts in primary cluster 2. Since the clustering algorithm does not use statistical criteria like *F*-values or *t*-values to determine differences in groups, many of the reported differences, while interesting, are statistically insignificant.

Contracts in primary cluster 1 are slightly smaller than those in cluster 2, with a mean deal of \$36 million, compared with \$42 million. They are also slightly less likely to involve up-front payments and slightly shorter, but they are more likely to contain up-front contract extension provisions, and the up-front payments, when present, are slightly larger.

When we compare the frequency, magnitude, and type of equity stakes, we see that the two clusters are again similar. There are statistically significant differences, however, in the control rights and follow-on provisions associated with the equity across the two clusters. All 12 contracts involving board seats fall into

¹⁴ We restrict our attention to dichotomous contract characteristics so that all characteristics have the same scale. This prevents the clustering algorithm from giving undue weight to something like the size of the equity stake, which is scaled in millions.

Table 13
Cluster Analysis of Contract Characteristics

Characteristics	Primary Cluster 1	Primary Cluster 2
Deal size	36.64	41.92
Fraction with up-front payments	.58	.66
Mean up-front payment size	3.18	2.85
Research term (mean years)	3.47	3.89
Extendable?	.58	.43
Equity characteristics:		
Client took equity	.68	.62
Mean equity stake size	8.12	7.30
Client took common equity	.38	.29
Client took preferred equity	.30	.33
Client took board seat*	0	.12
Loan tie-in ⁺	.15	.04
IPO tie-in ⁺	.30	.13
IPO tie-ins, only preferred*	.50	.16
Research tie-ins	.11	.26
Research tie-ins, only common*	.07	.36
Control characteristics, equity = 1:		
Employment provisions	.43	.54
Specifies full-time equivalent requirements ⁺	.33	.55
Specifies pay grade provisions	.07	.15
Severe termination provisions**	0	1.0
Oversight committee	.07	.13

Note. Characteristics are reported of an average linkage hierarchical cluster performed on the following contract characteristics: equity participation, up-front payment dummy, board seat dummy, research committee dummy, oversight committee dummy, initial public offering (IPO) tie-in, loan tie-in, research tie-in, and whether the deal included amicable or probationary termination provisions. The resulting hierarchical cluster was broken into two groups. Cluster 1 contains 40 contracts, and cluster 2 contains 76. The nine contracts that are not present are omitted from the analysis either because they had missing data or because they contained extreme outliers.

⁺ Significant at the 10% level.

* Significant at the 5% level.

** Significant at the 1% level.

cluster 2, while the equity stakes that fall into cluster 1 are more likely to involve tie-in provisions that the partner would find favorable.

Twenty percent of the deals in cluster 1 contain IPO tie-ins, meaning that the client firm agrees in advance to participate in a future IPO of the partner provided that it occurs within certain parameters. Only 13 percent of contracts in cluster 2 contain such provisions. Since Kaplan and Strömberg (2003), Sahlman (1990), and others have shown that preferred equity is a dominant form of investment among VC firms, we repeat the comparison but focus only on the deals that contain preferred equity in the two clusters. There the difference is even stronger: half the deals in cluster 1 contain IPO tie-ins, while only 16 percent of those in cluster 2 do.

Similarly, nearly 4 times as many equity contracts in cluster 1 tie the equity stake to the provision of loans. Equity stakes in cluster 1 are also much less likely to be tied to research milestones. One-quarter of equity deals in cluster 2 contain research tie-ins, while only about 10 percent of those in cluster 1 contain

Table 14
Explaining High-Trust Contracts

	(1)	(2)	(3)	(4)
Research term	-.167 ⁺ (.07)	-.188 ⁺ (.06)	-.191 ⁺ (.06)	-.218* (.04)
Client prior deals	.011 (.43)	.012 (.44)	.011 (.49)	.007 (.64)
Partner prior deals	.113* (.03)	.174** (.01)	.169** (.01)	.158* (.01)
Partner size		-.006* (.03)	-.006* (.03)	-.007* (.02)
Partner public status			.153 (.65)	.403 (.27)
Project stage				-.650 ⁺ (.09)
Constant	-.620 (.16)	-.253 (.60)	-.232 (.64)	.676 (.34)

Note. Probit regressions are reported in which the dependent variable is a dummy for whether the contract in question belongs to cluster 1 in the previous table. These are labeled high-trust contracts because, unlike other contracts, they generally do not specify oversight committees and they do not contain severe termination provisions. The *p*-values are reported in parentheses below point estimates.

⁺ Significant at the 10% level.

* Significant at the 5% level.

** Significant at the 1% level.

such provisions. When we focus on common equity only (preferred equity often contains convertibility provisions that potentially make research tie-ins redundant), the difference in the two clusters widens and becomes highly statistically significant. Equity stakes in cluster 1 are much less likely to be made contingent on research progress.

Thus, while equity is used in similar proportions across the two clusters, it appears to be used in a different manner, or perhaps with a slightly different purpose in mind. In cluster 2, it appears to be more commonly used as a control device, whereas in cluster 1 might be better characterized as a means of signaling the client's belief in the quality of the partner firm.

Further evidence in line with this interpretation can be seen by comparing other control provisions in the contract. Since we aim to see how equity is used differently across the two clusters, we focus on deals containing equity in the two clusters and ask how the control provisions vary.¹⁵ In general, contracts in cluster 1 are less likely to contain employment provisions; the difference is significant at the 8 percent level when we focus exclusively on provisions stating the number of FTEs allocated to projects. Moreover, none of the deals in cluster 1 contain severe termination provisions, while all the equity deals in cluster 2 contain severe termination provisions. (If we include nonequity deals, this distinction is still highly statistically significant: no deals, equity or otherwise, in cluster 1 contain severe termination, while only one deal in cluster 2 does not.) Finally, deals in cluster 1 are less likely to involve the use of oversight committees, although this difference lies just outside the 10 percent level.

¹⁵ The comparison is similar, but often slightly weaker, when we include nonequity deals, since across both clusters nonequity deals tend to include these control provisions at a similar frequency.

8.2. *Explaining the Clusters*

Next we turn to the task of trying to explain what firm and deal characteristics are correlated with the patterns of contract provisions we see from Table 13. To do this, we estimate probit models of the probability that a contract lies in cluster 1 based on characteristics of the firm pair and of the project. This is presented in Table 14.

Since the characteristics of deals in cluster 1 suggest that these contracts involve less control than those in cluster 2, we label deals in this cluster “high-trust deals.” This is purely for the sake of exposition. In model 1, we estimate the probability of being a high-trust deal as a function of the length of the project and the number of client and partner prior deals. Not surprisingly, the number of partner prior deals is positive and highly statistically significant. Also intuitive is the negative loading on the contract length, since shorter contracts are less subject to holdup problems (Monteverde and Teece 1982). These loadings continue to be significant when we add the size of the partner firm in column 2. Interestingly, the loading on size is negative: smaller partner firms are more likely to have high-trust contracts, all else being equal. Again, this is consistent with the idea that clusters of control provisions are used to combat holdup problems, since smaller partner firms presumably have fewer outside options and thus fewer incentives to hold up the client.

In column 3, we add a dummy for whether the partner firm is publicly traded. Publicly traded firms are generally older and are also subject to more financial oversight and market discipline. These facts would suggest that public partner firms would be more likely to receive high-trust contracts, since the client can rely on a broader set of extracontractual provisions. However, we find the loading on the public dummy to be insignificant, which perhaps indicates that the project-specific knowledge the two partners share supersedes the firm-specific knowledge available through public capital markets.

Finally, in column 4 we add the project stage variable. The loading indicates that higher trust contracts are associated with earlier stage deals. Since earlier stage deals are often considered to be fraught with greater uncertainty, this result may seem surprising; however, it is important to note that this finding holds constant the term length of the contract and the client and partner firms’ prior histories: the unconditional loading on project stage (not reported) is essentially flat. Also, the output from earlier stage deals may be more difficult for the partner firm to commercialize on its own, making high-trust contracting a more viable option.

To conclude, considering multiple contract provisions simultaneously enriches our understanding of the trade-offs present in real world contracts. When we consider the multitude of tag-on features that accompany equity, we find that the use of equity serves two purposes. On the one hand, it can be used to signal credibility. This is more common for smaller, better connected partners or for short-term deals where holdup problems may be less severe. On the other hand,

it can be used to exercise control. This is more common for larger, less well connected partners engaged in longer term projects. While we are still far from a causal model of contract design, these findings shed further light on the interplay among contractual provisions, reputation, and incomplete contracts.

9. Conclusion

This work examines 125 strategic alliance agreements in which large pharmaceutical organizations sponsor research at small biotechnology R&D firms. Each agreement centers on using the R&D firm's expertise in genomics to discover drug candidates that may later become part of the pharmaceutical's product pipeline. In general, deals such as these are a major source of funding to young biotechnology firms.

Focusing on alliances to conduct early-stage research at nascent (often pre-IPO) firms naturally suggests a comparison to VC. Like VC deals, almost all alliances involve staged capital infusions that are triggered when prespecified milestones are reached. Alliance contracts commonly involve convertible preferred equity and debt. Analogous to liquidation rights in VC, alliance contracts also clearly specify detailed termination provisions.

The provisions commonly associated with equity participation in strategic alliance contracts suggest that strategic alliance partners play a certification role in the IPO process of young biotech firms. Given that 40 percent of deals in our sample explicitly spell out the client's participation in a future IPO, an important topic for future research is understanding the role of strategic alliance partners in the book-building process and more generally understanding how the presence of alliance partners complements or substitutes for other certification mechanisms in the going public process.

Despite the many similarities, however, the analogy to VC falls well short of explaining the full complexity of strategic alliance agreements. A key distinction between VC and alliance activity lies in the different incentives for monitoring associated with providing a firm with capital versus providing a project with capital. Our research shows that alliance partners trade the board-level control common in VC arrangements with project-level oversight committees. This suggests that an important issue for future research is to study how entrepreneurs choose between project-level and firm-level funding and how this choice is affected by the securities used in the deal. For example, by taking an equity position in a partner firm, a client's incentives become more closely aligned to the total firm value of the partner rather than simply to the value of one of the partner's projects.

While the theory of incomplete contracts is a powerful tool for understanding the strategic alliance contracts we study, our results show that the contracting problems posed in alliances are solved through a blend of ownership allocation, explicit contractual clauses, and implicit contracts enforced through relational incentives. This suggests that a fruitful line of inquiry for theoretical research

lies in understanding how contracts reflect an optimal balance of these alternative governance mechanisms or how certain contractual clauses inoculate contracting parties against holdup, but only when other conditions are in place. Indeed, further study of strategic alliance contracts is likely to shed light on many important questions related to financial contracting.

References

- Aghion, Philippe, and Patrick Bolton. 1992. An Incomplete Contracts Approach to Financial Contracting. *Review of Economic Studies* 59(3):473–94.
- Allen, Jeffrey W., and Gordon M. Phillips. 2000. Corporate Equity Ownership, Strategic Alliances, and Product Market Relationships. *Journal of Finance* 55(6):2791–2815.
- Arruñada, Benito, Luis Garicano, and Luis Vázquez. 2001. Contractual Allocation of Decision Rights and Incentives: The Case of Automobile Distribution. *Journal of Law, Economics, and Organization* 17:257–84.
- Baker, George, Robert Gibbons, and Kevin J. Murphy. 1994. Subjective Performance Measures in Optimal Incentive Contracts. *Quarterly Journal of Economics* 109(4): 1125–56.
- . 2002. Relational Contracts and the Theory of the Firm. *Quarterly Journal of Economics* 117(1):39–84.
- . 2004. Strategic Alliances: Bridges between “Islands of Conscious Power.” Working paper. Harvard Business School, Cambridge, Mass.
- Bolton, Patrick, and David S. Scharfstein. 1990. A Theory of Predation Based on Agency Problems in Financial Contracting. *American Economic Review* 80(1):94–106.
- Bonacich, Phillip. 1987. Power and Centrality: A Family of Measures. *American Journal of Sociology* 92:1170–82.
- Crocker, Keith J., and Kenneth J. Reynolds. 1993. The Efficiency of Incomplete Contracts: An Empirical Analysis of Air Force Engine Procurement. *RAND Journal of Economics* 24:126–46.
- Diamond, Douglas W. 1984. Financial Intermediation and Delegated Monitoring. *Review of Economic Studies* 51:393–414.
- DiMasi, Joseph A., Ronald W. Hansen, and Henry Grabowski. 2003. The Price of Innovation: New Evidence of Drug Development Costs. *Journal of Health Economics* 22: 151–85.
- DiMasi, Joseph A., Ronald W. Hansen, Henry G. Grabowski, and Louis Lasagna. 1990. Cost of Innovation in the Pharmaceutical Industry. *Journal of Health Economics* 10: 107–42.
- Goldberg, Victor P. 2000. In Search of Best Efforts: Reinterpreting *Bloor v. Falstaff*. *Saint Louis University Law Journal* 44:1465–85.
- Grabowski, Henry, and John Vernon. 1990. A New Look at Returns and Risks in Pharmaceutical R&D. *Management Science* 36:804–21.
- Grossman, Sanford J., and Oliver D. Hart. 1986. The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration. *Journal of Political Economy* 94:691–719.
- Gulati, Ranjay. 1995. Does Familiarity Breed Trust? The Implications of Repeated Ties for Contractual Choice in Alliances. *Academy of Management Journal* 38:85–112.
- Hart, Oliver, and John Moore. 1990. Property Rights and the Nature of the Firm. *Journal of Political Economy* 98(6):1119–58.

- . 1994. A Theory of Debt Based on the Inalienability of Human Capital. *Quarterly Journal of Economics* 109(4):841–79.
- . 1998. Default and Renegotiation: A Dynamic Model of Debt. *Quarterly Journal of Economics* 113(1):1–41.
- Holmström, Bengt, and Paul Milgrom. 1991. Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design. *Journal of Law, Economics, and Organization* 7:24–51.
- Kaplan, Steven N., and Per Strömberg. 2003. Financial Contracting Theory Meets the Real World: Evidence from Venture Capital Contracts. *Review of Economic Studies* 70(2): 281–316.
- Klein, Benjamin, and Keith B. Leffler. 1981. The Role of Market Forces in Assuring Contractual Performance. *Journal of Political Economy* 89:615–41.
- Lerner, Josh, and Robert P. Merges. 1998. The Control of Strategic Alliances: An Empirical Analysis of Biotechnology Collaborations. *Journal of Industrial Economics* 46:125–56.
- Lerner, Josh, Hilary Shane, and Alexander Tsai. 2003. Do Equity Financing Cycles Matter? Evidence from Biotechnology Alliances. *Journal of Financial Economics* 67(3):411–46.
- Monteverde, Kirk, and David J. Teece. 1982. Supplier Switching Costs and Vertical Integration in the Automobile Industry. *Bell Journal of Economics* 13:206–13.
- National Science Board. 2000. Science and Engineering Indicators—2000. Technical report NSB-00-1. National Science Foundation, Arlington, Va.
- National Science Foundation. 1998. Science and Engineering Indicators, 1998. Detailed Statistical Tables NSF 98-331. National Science Foundation, Division of Science Resources Studies, Arlington, Va.
- Nöldeke, Georg, and Klaus M. Schmidt. 1995. Option Contracts and Renegotiation: A Solution to the Hold-up Problem. *RAND Journal of Economics* 26:163–79.
- . 1998. Sequential Investments and Options to Own. *RAND Journal of Economics* 29:633–53.
- Pisano, Gary P. 1989. Using Equity Participation to Support Exchange: Evidence from the Biotechnology Industry. *Journal of Law, Economics, and Organization* 5(1):109–26.
- Podolny, Joel M., 1993. A Status-Based Model of Market Competition. *American Journal of Sociology* 98:829–72.
- Robinson, David T. 2008. Strategic Alliances and the Boundaries of the Firm. *Review of Financial Studies* 21:649–81.
- Robinson, David T., and Toby E. Stuart. 2007. Network Effects in the Governance of Biotech Strategic Alliances. *Journal of Law, Economics, and Organization* 23(1):242–73.
- Sahlman, William A. 1990. The Structure and Governance of Venture-Capital Organizations. *Journal of Financial Economics* 27:473–521.
- Scott, Robert E., and George G. Triantis. 2005. Anticipating Litigation by Contract Design. *Yale Law Journal* 115:814–79.
- Sorenson, Olav, and Toby E. Stuart. 2001. Syndication Networks and the Spatial Distribution of Venture Capital Investments. *American Journal of Sociology* 106:1546–86.
- Williamson, Oliver E. 1975. *Markets and Hierarchies: Analysis and Antitrust Implications*. New York: Free Press.
- Wong, Andrew. 2001. *Angel Investors*. Ph.D dissertation. University of Chicago, Graduate School of Business, Chicago.