AGENCY AND STRATEGIC CONTRACTS: THEORY AND EVIDENCE FROM R&D AGREEMENTS IN THE PHARMACEUTICAL INDUSTRY

Di Guo, Xinyu Hua, and Kun Jiang[1]

Abstract

We examine the use of strategic rights in research and development (R&D) agreements between a client and an agent, when an entrant may compete with the client for the license of non-contracted discoveries developed by the agent. The agent puts effort either in the contracted project, or into other R&D activities which can result in non-contracted discoveries. Strategic rights help the client and the agent extract rent from the entrant, and also motivate the agent to place effort into the contracted project. Accordingly, firms are more likely to adopt strategic rights when the likelihood of entry is larger. Moreover, strategic rights and termination rights are substitutes in mitigating agency problems. By investigating R&D agreements between pharmaceutical clients and bio-tech agents, we find consistent evidence of the positive impact of entry threat on the use of strategic rights, as well as evidence of the substitution between strategic rights and termination rights.

Keywords: Agency, Entry Threat, Strategic Right, Termination
JEL Classifications: D86, L22, L24, O30

[1] Di Guo: Center of China Financial Research, University of Hong Kong, Pokfulam Rd., Hong Kong Island, Hong Kong (e-mail: guodi2007@gmail.com);
Xinyu Hua: Department of Economics, Hong Kong University of Science and Technology, 6th Floor, LSK Business Building, Clear Water Bay, Hong Kong (e-mail: xyhua@ust.hk);
Kun Jiang: Business School, University of Roehampton, Roehampton Lane, London SW15 5SL, UK (e-mail: kun.jiang@roehampton.ac.uk).
We would like to thank two referees, one editor, Yongmin Chen, Jay Pil Choi, James Dana, David Dranove, Darren Filson, Yuk-fai Fong, Oliver Hart, Francine Lafontaine, Susan Lu, Thomas Ross, Alan Schwartz, Robert Scott, Kathryn Spier, Guofu Tan, and Chenggang Xu for their valuable comments. We would also like to thank the seminar participants at HKUST, Peking University, Yonsei University, the 23rd Annual Meeting of the American Law and Economics Association, the 11th Annual International Industrial Organization Conference, and the 42nd Annual Conference of the European Association for Research in Industrial Economics. We thank Whitney Chan, Kai Lung Chung, Andy Ko, Joshua Wong, and David Yiu for their excellent research assistance. Di Guo would like to thank the University of Hong Kong for financial support. Xinyu Hua thanks the Hong Kong Research Grants Council for their financial support (Grant Number: 691113). All mistakes remain our own.

1. Introduction

Strategic rights are contract clauses used as strategic tools against entrants. These rights are widely adopted in sales, acquisitions, and strategic alliances, when contracts are incomplete and entry threat exists. In particular, research and development (R&D) agreements between clients and agents are often incomplete, because these firms cannot anticipate or specify all of the potential discoveries. Consequently, other firms can then enter and compete for the licensing rights of the non-contracted discoveries developed by the agents. Thus, the agents may devote more effort to non-contracted R&D activities, instead of the activities specified in the agreements.

In practice, R&D agreements often include strategic rights, which provide some advantage to clients against entrants in their competition for the licensing of non-contracted discoveries. For example, the *most favored licensee clause* and *the right of first refusal* between a client and an agent typically specify that, if the agent develops a non-contracted discovery and receives an offer from another potential licensee, the agent must inform the client and the client then has the right to obtain the license by matching the outside offer.[2]

The theoretical literature (e.g., Aghion and Bolton, 1987) shows that strategic contracts can help extracting rent from entrants and protect investments of the contracting parties. However, little formal analysis has been performed on how strategic contracts affect agents' R&D incentives or how strategic rights interact with other contract terms, such as termination rights.[3] This paper provides a theoretical analysis, together with empirical evidence, that aims to shed light on these issues.

We consider a model where, after a client devotes investments and hires an agent to conduct an R&D project, the agent can allocate effort to either the contracted project or other non-contracted R&D activities. A potential entrant may compete for the license of non-contracted discoveries. In the benchmark case without any strategic right, the licensing of non-contracted discoveries follows standard first-price or second-price auctions. A larger likelihood of entry increases the agent's incentive to shift effort into

[2] A related but different clause, *the right of first offer*, requires the agent to first make an offer to the client. If the client rejects the offer, the agent can look for other buyers/licensees but cannot sell the license in more favorable terms than the offer extended to the initial client. Firms may also use other clauses, such as *rights of first discussions/considerations*, which require agents to negotiate with clients before searching for other buyers, but often do not set restrictions on sales terms.

[3] Termination rights without cause allow clients to terminate projects without pre-specified conditions.

non-contracted R&D activities. Consequently, the client might not make jointly beneficial investments.

We illustrate the effects of strategic rights by analyzing the right of first refusal, and then, more generally, characterize the optimal strategic contract for the client who has all the bargaining power.[4] Adopting strategic rights increases the client's contracting costs. However, compared to standard auctions, strategic rights offer the client a larger winning probability in the competition over non-contracted discoveries and reduce the agent's expected revenue from non-contracted discoveries. Thus, strategic rights not only help the contracting parties extract more rent from the entrant, but also enhance the agent's incentives to exert effort in the contracted project. A larger likelihood of entry uplifts both effects and, consequently, increases the firms' incentives to adopt strategic rights. Moreover, we show that strategic rights and termination rights are substitutes in mitigating agency problems.

The theoretical analysis suggests that firms may have different incentives for using strategic rights, which we observe in practice. For example, among nine R&D agreements signed between Abbott, a pharmaceutical firm, and various agents between 1992 and 1998, three agreements adopted the right of first refusal while the others did not include any strategic right.[5] More generally, using a dataset of R&D agreements between pharmaceutical firms and bio-tech agents, we obtain empirical observations that firms are more likely to include strategic rights in R&D agreements when the potential entry threat for the licensing of non-contracted discoveries is larger. More importantly, we find a negative correlation between the use of strategic rights and the use of termination rights which allow clients to terminate projects without cause. These observations are consistent with our theoretical predictions.

Our paper contributes to the theoretical literature on strategic contracts. Contracts can be used as strategic tools to extract rent from entrants (Aghion and Bolton, 1987). Strategic contracts can also preserve incentives for relationship-specific investments (Rogerson, 1984, 1992; Chung, 1991; Spier and Whinston, 1995; Che and Chung, 1999; Che and Hausch, 1999; Segal and Whinston, 2000; Che and Lewis, 2007) and facilitate trade (Hua, 2007; Matouschek and Ramezzana, 2007). Bikhchandani, Lippman, and Ryan (2005), Choi (2009), Grosskopf and Roth (2009), and Hua (2012) analyze the use

[4] The main insights hold qualitatively if the agent also has some bargaining power.
[5] The observations are based on the Recap dataset, which we will describe in Section 4.

of the right of first refusal and/or the right of first offer. Other studies examine the most favored customer clauses (Butz, 1990; Cooper and Fries, 1991; Daughety and Reinganum, 2004). Different from the literature, our study illustrates the effect of strategic contracts in mitigating agency problems, as well as the relationship between strategic rights and termination rights. We also provide empirical evidence on both the adoption of strategic rights and the relationship between strategic rights and termination rights.[6]

Our paper is also related to the empirical studies on contracts in several dimensions.[7] First, our paper complements the studies on control rights and contingent contracts (Caves et al., 1983; Lerner and Merges, 1998; Anand and Khanna, 2000; Arrunada, Garicano, and Vazquez, 2001; Kaplan and Strömberg, 2003; Elfenbein and Lerner, 2003; Lerner and Schoar, 2005; Ryall and Sampson, 2009; Zanarone, 2009; Lerner and Malmendier, 2010; Susarla, 2012; Crama et al., 2016; Elfenbein and Lerner, forthcoming). Second, our paper attempts to answer an important but understudied question: what the interaction is among different contract clauses. To date, a few studies have shown complementarity among certain contract terms (Brickley, 1999; Lafontaine and Raynaud, 2002; Hueth et al., 2008). Our analysis provides evidence of a possible substitution relationship between strategic rights and termination rights. Third, by considering entry threat and agency issues, our paper also contributes to the empirical literature on exclusive dealing (Marvel, 1982; Heide et al., 1998; Dutta et al., 1999; Zanarone, 2009) and the literature on share contracts (Brickley and Dark, 1987; Lafontaine, 1992, 1993; Gil and Lafontaine, 2012). Different from the literature, our paper focuses on the adoption of strategic rights, as well as the relationship between strategic rights and termination rights.

The rest of this paper is organized as follows. Section 2 formulates the model. Section 3 analyzes the effects of strategic rights as well as the relationship between strategic and termination rights. Section 4 describes the data and Section 5 presents the empirical observations. Section 6 concludes the paper. All the proofs and tables are gathered in the appendices.

[6] Grosskopf and Roth (2009) conduct an interesting experimental study on the right of first refusal. Crocker and Lyon (1994) study the effects of the most favored nation clauses on product market competition.

[7] See Lafontaine and Slade (2012) for a more detailed summary of the literature.

2. The Model

Consider three risk-neutral players: a client *P*, an R&D agent *A*, and an entrant *E*. *E* arrives with probability $\theta > 0$ after *P* and *A* enter into an R&D contract.[8] θ can be interpreted as the degree of entry threat. We focus on the competition between *P* and *E* for obtaining the licenses of R&D discoveries, instead of product market competition, where the firms develop and sell two different products.[9] We also abstract away from the possibility for *P* and *E* to obtain licenses for the same discovery.

P can make capital investment $I>0$ and hire *A* to conduct one R&D project *C*, looking for a particular discovery *D*. At the same time, *A* has another private R&D project *NC*, which, without extra capital and effort, results in some discovery with probability β. However, by shifting the investment and effort to Project *NC*, *A* can increase the probability of finding a discovery from Project *NC* to $\alpha + \beta$, where $\alpha < 1 - \beta$. We assume that Project *C* is contractible while Project *NC* is non-contractible.[10] Accordingly, we call the discovery from Project *C* the contracted discovery and discoveries from Project *NC* the non-contracted discoveries.[11]

After signing the R&D contract, *A* privately allocates the investment and effort, $e \in \{C, NC\}$, into either Project *C* or Project *NC*, but not both. To simplify the analysis, assume that the effort cost is zero.

If $e = C$, with probability α, *A* finds the contracted discovery *D*; independently with probability β, he obtains a non-contracted discovery.

If $e = NC$, with probability $\alpha + \beta$, he finds a non-contracted discovery but never obtains the contracted discovery.

We assume that *A* lacks the necessary production and marketing resources, and therefore, the realization of any value from discoveries requires licensing to *P* or *E*. The market value of the contracted discovery is $u > 0$, which is commonly known.

In contrast, the value of a non-contracted discovery is uncertain before it is found, reflecting the fact that it may come from a large pool of possible discoveries. Moreover,

[8] We do not consider potential mergers between clients and agents, which are possible in practice but can be costly. Also, without loss of generality, we consider only one entrant in the model.

[9] Product market competition can affect the agent's R&D effort, but does not motivate firms to use the strategic rights analyzed in this paper.

[10] For example, Project *NC* may lead to one of many potential discoveries, and therefore, is not contractible.

[11] We ignore possible complementarity or substitution between different discoveries, as analyzed by Hart, Shleifer, and Vishny (1997) in an agency framework without entry threat.

P and *E* may derive different values, v_P and v_E, from the non-contracted discovery. v_P and v_E are independent and drawn from the same distribution $F(v)$, with $f(v) > 0$ for any $v \in [\underline{v}, \overline{v}]$ and a monotone hazard rate: $H(v) = (1 - F(v))/f(v)$ decreasing in v. Each firm privately observes his value after the non-contracted discovery is found.[12]

Define $\hat{v} = \int_{\underline{v}}^{\overline{v}} \int_{\underline{v}}^{\overline{v}} \max(v_P, v_E)\, dF(v_p) dF(v_E)$. Throughout the paper, assume that $\frac{I}{\hat{v}} > \alpha \geq \underline{\alpha} \equiv \frac{I}{u}$. That is, it is socially efficient for *P* to make the investment and for *A* to put effort into Project *C*, whereas it is never efficient to put effort into Project *NC*. However, a moral hazard problem exists in that *A* may put effort into Project *NC*.

We abstract away from any asymmetric information which may exist between *P* and *A* in the contracting stage. This admittedly strong assumption simplifies the analysis. Without loss of generality, we assume that *P* has all the bargaining power and can make a take-it-or-leave-it contract offer. Thus, the optimal contract should maximize *P*'s expected utility. Thus, the optimal contract always gives *P* the license of the contracted discovery.

The R&D contract specifies an ex-post royalty payment $r \geq 0$ from *P* to *A*, conditional on finding the contracted discovery.[13] To be realistic, assume that *A* has no capital and *P* has sufficient capital to make the royalty payment.[14] Therefore, the total expected payment from *P* to *A* cannot be negative.

The contract can also include some clause or mechanism for the licensing of any non-contracted discovery. Adding such a clause would increase *P*'s contracting cost by $\delta > 0$.[15] Without such a clause, when a non-contracted discovery is found and *E* enters, *P* and *E* compete in a standard first-price or second-price auction; when *E* does not arrive, *P* is the only buyer, and therefore, has all the bargaining power in negotiating with the agent.

Finally, the contract can contain a termination right which allows *P* to terminate the contract without cause. Adding such a right would also increase *P*'s contracting cost by

[12] We also examine a variant of the model where *P* observes v_P before contracting. Our main results regarding the effects of strategic contracts remain robust (see Appendix C).

[13] In practice, royalty payments can depend on sales volume. We abstract away from this possibility by assuming that the market value of the contracted discovery is fixed at u. Therefore, without loss of generality, royalty can be simplified as an ex-post flat payment in the model.

[14] As shown by Hua (2007), *P*'s financial constraint can affect the design of strategic contracts. Including a financial constraint would complicate the analysis without generating extra insights in this paper.

[15] Contracting costs include extra time or effort when negotiating and implementing the mechanism. Our results remain valid regardless of whether *P* or *A* bears such costs.

$\delta > 0$. After *A* puts in effort, with probability $\phi \leq 1$, *P* observes a non-verifiable signal $s \in \{1, 0\}$ about the progress of Project *C*. If $s = 1$, Project *C* will be successful with the contracted discovery developed; if $s = 0$, Project *C* will fail.[16] Note that *A*'s effort choice will affect the probability of observing the signal. If *A* has chosen $e = C$, then *P* observes $s = 1$ with probability $\alpha\phi$, observes $s = 0$ with probability $(1 - \alpha)\phi$, and does not get any signal with probability $1 - \phi$. If *A* has chosen $e = NC$, then *P* observes $s = 0$ with probability ϕ and does not get any signal with probability $1 - \phi$.

The assumption that s is non-verifiable reflects the reality that, in many R&D projects, the progress is hard to be verified by the courts or outsiders. Thus, we focus on the termination right without cause, which gives the client more flexibility than the termination right with conditions.[17] It would be meaningful to relax this assumption and examine the differences among various termination rights in future research.

Upon observing the signal, *P* decides whether or not to exercise the termination right. If so, he obtains a residual value w, which reflects the potential savings of the investment costs. [18] If the contract is terminated, the contracted discovery is not developed, whereas *A* finds a non-contracted discovery with probability β, regardless of whether he has put effort into Project *C* or *NC*. Assume that $\alpha\hat{v} < w < \alpha u$ and $(1 - \alpha)w > \delta$. Thus, if *P* always observes the signal, the expected savings of investment costs, $(1 - \alpha)w$, is larger than the contracting cost to include the termination right.

The above-mentioned termination right works in a way similar to staged financing, which, as illustrated in the literature, can motivate agents to exert effort.[19] In many R&D agreements, it is difficult to specify verifiable "stages" of progress. In practice, staged financing often requires clients to continue financing upon observing *positive and verifiable signals* about the progress of the contracted projects, while termination rights without cause allow clients to discontinue the projects upon observing *negative and possibly non-verifiable signals* about the progress of the projects or associated agency problems.

---

[16] The main results in this paper still hold if *s* is a noisy signal about the progress of Project *C*.

[17] A more general model can consider a signal which is verifiable, but only with some probability. If this is the case, both termination rights without cause and with conditions can be included.

[18] In practice, R&D agreements may also specify, upon termination, how to allocate the ownership of current or potential discoveries between clients and agents. We abstract away from such complications. As long as the termination reduces the probability of finding discoveries, the main results hold.

[19] For examples, see Admati and Pfleiderer (1994), Bergemann and Hege (1998), and Neher (1999).

As shown in Figure 1, the timing is as follows:

Date 1: *P* makes a take-it-or-leave-it contract offer to *A*. If *A* rejects the offer, the game moves to Date 4. If *A* accepts, *P* makes the investment I.

Date 2: *A* chooses the investment target as well as effort $e \in \{C, NC\}$, which is unobservable to any other player.

Date 3: *P* observes a non-verifiable signal $s \in \{1, 0\}$ with probability $\phi \leq 1$ and decides whether to exercise the termination right if it is specified in the contract.

Date 4: R&D outcomes are realized. Whenever *A* finds a non-contracted discovery, *E* enters with probability θ. In addition, *P* and *E* (if he arrives) privately observe their values on that discovery.

Date 5: If the R&D contract between *P* and *A* includes a mechanism regarding the licensing of non-contracted discoveries, the allocation of the license is determined by that mechanism; otherwise, the allocation is determined by the standard first-price or second-price auction.

(Insert Figure 1 here)

3. Theoretical Analysis of Strategic Rights

Various strategic rights share the same feature of giving initial clients a competitive advantage against entrants. Instead of having a lengthy analysis of all strategic rights, we will first illustrate the effects of strategic rights by examining the right of first refusal. Then we will follow the approach in Hua (2007) to characterize the optimal strategic contract for client *P*. At the end, we will examine the relationship between strategic rights and termination rights without cause.

As a benchmark, suppose that the R&D contract between *P* and *A* does not include a termination right or any mechanism regarding the licensing of non-contracted discoveries. If *A* develops a non-contracted discovery, two scenarios emerge:

First, when *E* arrives, *P* and *E* compete in the standard first-price or second-price auction. Accordingly, if $v_E \leq v_P$, *P* wins the license with the expected payment of v_E to *A*; otherwise, *E* wins with the expected payment of v_P to *A*.

Second, when *E* does not enter, *P* obtains the license with zero payment.

Under both scenarios, the joint benefit for *P* and *A* from the non-contracted discovery equals v_P. *A*'s expected revenue from the non-contracted discovery is θR_0, $where\ R_0 \equiv \int_{\underline{v}}^{\overline{v}}[\int_{\underline{v}}^{v_P} v_E dF(v_E) + \int_{v_P}^{\overline{v}} v_P dF(v_E)]dF(v_P)$.

Suppose that *P* and *A* have signed a R&D contract. At Date 2, *A* would put effort into Project *C* if and only if:

$$\alpha r + \beta\theta R_0 \geq (\alpha + \beta)\theta R_0$$

or equivalently, $r \geq \theta R_0$.

Given that *P* has all the bargaining power, he would offer a royalty payment $r_0 = \theta R_0$. Thus, at Date 1, *A*'s expected utility from both the contracted and non-contracted discoveries is $(\alpha + \beta)\theta R_0$. *P*'s expected utility from making the investment is $\alpha(u - \theta R_0) - I$, which is positive if and only if $\alpha > \alpha_0 \equiv \frac{I}{u - \theta R_0}$. Note that $\alpha_0 > \underline{\alpha} \equiv \frac{I}{u}$. Lemma 1 summarizes these observations.

Lemma 1: Suppose that the licensing of non-contracted discoveries is determined by the standard first-price or second-price auction. There exists a cut-off α_0, which increases in θ, such that if $\alpha > \alpha_0$, *P* makes the investment and offers *A* a royalty payment $r_0 = \theta R_0$; if $\underline{\alpha} < \alpha \leq \alpha_0$, *P* does not make the investment.

Intuitively, to solve the agency problem that *A* may shift the investment and effort into Project *NC*, *P* must offer a sufficiently large royalty payment, which can be too costly for *P*, and therefore, discourage *P* from making the investment, especially when the probability of finding the contracted discovery is not high.

3.1 Illustration with the Right of First Refusal

The right of first refusal (ROFR) requires that when *A* develops a non-contracted discovery and *E* enters, *E* first makes a bid and then *P* has the right to win the license by matching *E*'s bid. Choi (2009) shows that ROFR helps contracting parties extract more rent from entrants, but does not examine agents' incentives to contribute effort.

Suppose that *P* and *A* have signed one R&D contract including ROFR. If *A* develops a non-contracted discovery, two scenarios emerge: First, if *E* does not enter, *P* obtains the license with zero payment; second, if *E* arrives, he makes a bid *b* to buy the license

and then *P* matches *E*'s bid if and only if $v_P > b$. Anticipating this, *E* chooses the bid to maximize his expected utility:

$$Max_b(v_E - b)F(b)$$

Thus, *E*'s optimal bid $b_E = b_E(v_E)$ satisfies:

$$b_E + \frac{F(b_E)}{f(b_E)} = v_E.$$

Accordingly, given the non-contracted discovery, *A*'s expected revenue is $\theta R_{ROFR} \equiv \theta \int_{\underline{v}}^{\overline{v}} b_E(v_E)dF(v_E)$. The joint benefit for *P* and *A* is $\int_{\underline{v}}^{\overline{v}} \int_{\underline{v}}^{\overline{v}} \max\{v_P, b_E(v_E)\}dF(v_P)\,dF(v_E)$, larger than $\int_{\underline{v}}^{\overline{v}} v_P dF(v_P)$, their joint benefit under the standard auctions. It is easy to verify that *P*'s winning probability is higher than under the standard auctions. Intuitively, by giving *P* a larger winning probability, ROFR forces *E* to make a higher payment (whenever it wins) and therefore increases the joint benefit for *P* and *A* from non-contracted discoveries by $\beta\theta\Delta_{ROFR}$, where:

$$\Delta_{ROFR} = \int_{\underline{v}}^{\overline{v}} \int_{\underline{v}}^{\overline{v}} \max\{v_P, b_E(v_E)\}dF(v_P)\,dF(v_E) - \int_{\underline{v}}^{\overline{v}} v_P dF(v_P) > 0.$$

Furthermore, as shown in the mechanism design literature (Myerson, 1981), the standard auctions can maximize the seller's (here, the agent's) expected revenue. However, since ROFR distorts the competition between *P* and *E*, it reduces *A*'s expected revenue from the non-contracted discovery, that is, $\theta R_{ROFR} < \theta R_0$.[20] At Date 2, *A* would put effort into Project *C* if and only if:

$$\alpha r + \beta\theta R_{ROFR} \geq (\alpha + \beta)\theta R_{ROFR},$$

or, equivalently, $r \geq \theta R_{ROFR}$. At Date 1, *A* would accept the contract with ROFR if and only if his utility is larger than that without any R&D contract:

$$\alpha r + \beta\theta R_{ROFR} \geq \beta\theta R_0. \quad (1)$$

Without loss of generality, in this sub-section, assume that $(\alpha + \beta)\theta R_{ROFR} < \beta\theta R_0$.[21] Then, as long as condition (1) holds, *A* would put effort into Project *C*. Thus, given ROFR, *P* would offer a royalty payment of $r_{ROFR} = \frac{\beta\theta}{\alpha}(R_0 - R_{ROFR})$. Accordingly, *A*'s expected utility equals $\beta\theta R_0$, smaller than his utility in the benchmark case with

[20] The formal proof is similar to the analysis in the mechanism design literature and is therefore omitted.
[21] This assumption holds, for example, if β is sufficiently large. Without this assumption, the agent's expected utility would be higher than $\beta\theta R_0$, but still less than $(\alpha + \beta)\theta R_0$. Thus, the main result in Proposition 1 holds qualitatively.

standard auctions, $(\alpha+\beta)\theta R_0$. Intuitively, compared to the standard auctions, ROFR reduces *A*'s expected revenue from the non-contracted discoveries and enhances his incentive to put effort into Project *C*.

To summarize, ROFR not only helps the contracting parties extract more rent of $\beta\theta\Delta_{ROFR}$ from the entrant, but also reduces the agency cost by $\alpha\theta R_0$. Both the rent extraction effect and the reduction of the agency cost uplift *P*'s incentive to make the investment, which brings a net value of $\alpha u - I$. Note that both the rent extraction effect and the saving of the agency cost increase in θ. It then follows that *P* adopts ROFR when θ is sufficiently large.

Proposition 1: Given the other parameter values, a cut-off $\hat{\theta} > 0$ exists such that, if and only if the probability for *E* to enter is larger than $\hat{\theta}$, *P* will adopt ROFR in the R&D contract.

The analysis suggests that ROFR can help the contracting parties extract rent from the entrant and mitigate the agency problem. However, ROFR may not be the optimal strategic contract for *P*.

3.2 The Optimal Strategic Contract without Termination Rights

Now we derive the optimal strategic contract that maximizes *P*'s expected utility, without considering the termination right. In particular, we extend the analysis in Hua (2007) and focus on the direct revelation mechanism: when *A* develops a non-contracted discovery and *E* enters, *P* and *E* are asked to report their values. Given their reports, v_P, v_E, *P* and *E* obtain the license with probability $q_P(v_P, v_E)$ and $q_E(v_P, v_E)$, respectively, with ex-post payments $t_P(v_P, v_E)$ and $t_E(v_P, v_E)$ to *A*.[22] As in the literature on mechanism design, we use the following notations: for $i = P, E$, $Q_i(v_i) \equiv \int_{\underline{v}}^{\overline{v}} q_i(v_i, v_j) dF(v_j)$ is i's expected winning probability, given his reported value; $T_i(v_i)$ is i's expected payment to *A* for the non-contracted discovery.

[22] For simplicity, we do not consider reserve prices in the mechanism design. The reserve price does not affect our results qualitatively. We also do not observe the use of reserve prices in our contract dataset.

Define *A*'s ex-post revenue from the non-contracted discovery as $\theta R_1 \equiv \theta[\int_{\underline{v}}^{\overline{v}} T_P(v_P)\, dF(v_P) + \int_{\underline{v}}^{\overline{v}} T_E(v_E) dF(v_E)]$. Then, P would offer a contract $(r, Q_i, T_i), i = P\ and\ E$, to maximize his expected utility:

$$Max_{(r,Q_i,T_i)} \alpha(u - r) - I - \delta + \beta\left\{(1-\theta)\int_{\underline{v}}^{\overline{v}} v_P dF(v_P) + \theta\int_{\underline{v}}^{\overline{v}} [Q_P(v_P)v_P - T_P(v_P)]dF(v_P)\right\}$$

subject to: $Q_i(v)v - T_i(v) \geq Q_i(\tilde{v})v - T_i(\tilde{v})$ for all $i, v, \tilde{v}$ (IC)

$Q_i(v)v - T_i(v) \geq 0$ for all i, v (IR)

$\alpha r + \beta\theta R_1 \geq \beta\theta R_0$ (Ex-ante IR)

$\alpha r + \beta\theta R_1 \geq (\alpha + \beta)\theta R_1$ (Agent's Effort)

Recall that $\beta\theta R_0$ is *A*'s revenue from non-contracted discoveries in the benchmark case with standard auctions. The incentive compatibility constraint (IC) guarantees truth telling from *P* and *E*. The individual rationality constraint (IR) assumes that *A* cannot force *P* or *E* to pay a transfer higher than his value from the non-contracted discovery. Moreover, the ex-ante individual rationality constraint (Ex-ante IR) makes this contract acceptable to *A* and the agent's effort constraint assures that *A* puts effort into Project *C*.

Denote the solution to the problem as $(r^*, Q_i^*, T_i^*), i = P\ and\ E$. Note that, to motivate *A* to put effort into Project *C*, the royalty payment should satisfy $r^* \geq \theta R_1$, which, together with the ex-ante IR constraint, implies $(\alpha + \beta)\theta R_1 \geq \beta\theta R_0$. Under the optimal mechanism, this ex-ante IR constraint is binding; otherwise, *P* can increase his utility by reducing $T_P(v)$ (and R_1) for all v by a small amount. Therefore, we have $R_1 < R_0$. That is, compared to the standard auctions, the optimal mechanism reduces *A*'s expected revenue from non-contracted discoveries.

As shown in Appendix B, whenever a non-contracted discovery is found and *E* enters, *under the optimal mechanism*, if v_P is greater than $v_E - \frac{1-F(v_E)}{f(v_E)}$, *P* wins the license of the non-contracted discovery; otherwise, *E* wins. Compared to the standard auctions, this mechanism offers *P* a larger winning probability. Additionally, *E*'s expected ex-post payment to *A* is $T_E^*(v_E) = Q_E^*(v_E)v_E - \int_{\underline{v}}^{v_E} Q_E^*(x)dx$. *P*'s expected

ex-post payment to A is $T_P^*(v_P) = Q_P^*(v_P)v_P - \int_{\underline{v}}^{v_P} Q_P^*(x)dx - z$, where $z \geq 0$ is chosen such that $(\alpha + \beta)\theta R_1 = \beta\theta R_0$.

Similar to ROFR, the optimal mechanism brings two effects. First, given that *P* has a larger winning probability, *E* can win the license only when he is willing to make a large payment. Define

$$\Delta = \int_{\underline{v}}^{\overline{v}} Q_P^*(v_P)v_P dF(v_P) + \int_{\underline{v}}^{\overline{v}} T_E^*(v_E)dF(v_E) - \int_{\underline{v}}^{\overline{v}} v_P dF(v_P).$$

Note that, compared to the standard auctions, the optimal mechanism changes the (expected) joint benefit for *P* and *A* from the non-contracted discovery by $\beta\theta\Delta$. As shown in Appendix B, $\beta\theta\Delta > 0$.

Second, the optimal mechanism can also mitigate the agency problem. As shown earlier, compared to the standard auctions, the optimal mechanism reduces *A*'s expected revenue from non-contracted discoveries. Consequently, *A* has greater incentives to put effort into Project *C*. Note that *A*'s expected utility equals $\beta\theta R_0$, which is smaller than his utility in the benchmark case with the standard auctions, $(\alpha + \beta)\theta R_0$.

To summarize, the optimal mechanism helps to extract more rent $\beta\theta\Delta$ from the entrant and also reduces the agency cost by $\alpha\theta R_0$. Both effects enhance *P*'s incentive to make the investment, which brings a net value of $\alpha u - I$. Following this observation, we characterize *P*'s optimal contract in Lemma 2.

Lemma 2: *P* makes the investment if and only if $\alpha > \alpha_0$ or $\alpha \leq \alpha_0$ and $\alpha u - I + \beta\theta\Delta - \delta > 0$. When making the investment, if $\alpha > \alpha_0$ and $\beta\theta\Delta + \alpha\theta R_0 - \delta \leq 0$, *P* offers a royalty payment $r_0 = \theta R_0$ without any strategic mechanism; otherwise, *P* offers the contract with a royalty payment $r^* = \theta R_1$ and the following optimal strategic mechanism: whenever a non-contracted discovery is found and *E* enters, if v_P is greater than $v_E - \frac{1-F(v_E)}{f(v_E)}$, *P* wins the license; otherwise, *E* wins.

Note that both the rent extraction effect and the reduction of the agency cost increase in θ. Proposition 2 then follows.

Proposition 2: Given the other parameter values, a cut-off $\tilde{\theta} > 0$ exists such that, if and only if the probability for *E* to enter is larger than $\tilde{\theta}$, *P* adopts the optimal strategic mechanism for the licensing of non-contracted discoveries.

The analysis suggests that strategic rights help contracting parties extract more rent from entrants, and also mitigate agency problems and encourage clients to make investments. Accordingly, firms are more likely to adopt strategic rights when potential entry threat is larger. We will empirically investigate this prediction in Section 5.

3.3 Strategic Rights and Termination Rights

In this sub-section, consider the possibility of including a termination right in the R&D contract. Given the assumption $\hat{v} < w < \alpha u$, when holding the termination right, *P* would terminate the contract and obtain the residual value w at Date 3 when observing $s = 0$, but not terminate when he observes $s = 1$ or does not get any signal.[23]

Suppose that *P* and *A* have signed an R&D contract that includes a termination right but not any mechanism for the licensing of non-contracted discoveries. Given any non-contracted discovery, *A*'s expected revenue is θR_0. Note that if *A* puts effort into Project *NC*, *P* terminates the contract with probability ϕ and, therefore, the probability of *A* finding a non-contracted discovery is $\alpha(1-\phi)+\beta$. Thus, at Date 2, *A* would put effort into Project *C* if and only if:

$$\alpha r + \beta\theta R_0 \geq (\alpha(1-\phi)+\beta)\theta R_0,$$

or equivalently, $r \geq (1-\phi)\theta R_0$. By contrast, recall that in the benchmark case, *A* would put effort into Project *C* if and only if $r \geq \theta R_0$. Given the termination right, *P* would offer a royalty payment $r_T = (1-\phi)\theta R_0$, while *A* always accepts such a contract. Accordingly, *A*'s expected utility equals $(\alpha(1-\phi)+\beta)\theta R_0$, which is smaller than his utility in the benchmark case with the standard auctions, $(\alpha+\beta)\theta R_0$. That is, the termination right reduces the agency cost.

Note that both the strategic right and termination right can mitigate the agency problem. Therefore, these two clauses can be substitutes. However, the overall comparison of the two contract clauses is ambiguous. For simplicity, we focus on

[23] For simplicity, we ignore renegotiation after *A* puts in effort. Potentially, *P* could threaten to terminate the agreement and renegotiate with *A*, even when observing $s = 1$. However, as long as the residual value *w* is sufficiently smaller than u, such a threat is not credible.

parameter values under which, without a termination right, *P* would adopt the optimal strategic mechanism.

Proposition 3: Suppose that $\alpha > \alpha_0$ and $\beta\theta\Delta + \alpha\theta R_0 - \delta > 0$ or $\alpha \leq \alpha_0$ and $\alpha u - I + \beta\theta\Delta - \delta > 0$. There exist cut-offs $0 < \phi_L \leq \phi_H < 1$ and $\hat{\beta} > 0$: When $\phi \leq \phi_L$, *P* offers a royalty payment $r^* = \theta R_1$ together with the optimal strategic mechanism, but not the termination right; when $\phi \geq \phi_H$ and $\beta < \hat{\beta}$, *P* offers a royalty payment $r_T = (1-\phi)\theta R_0$, together with the termination right, but not the optimal strategic mechanism.

The results can be understood intuitively. When the probability of observing the interim signal is small, the termination right is not overly effective. Consequently, *P* would adopt the strategic mechanism to extract more rent from *E* and mitigate the agency problem. In contrast, when the probability of observing the interim signal is large enough, the termination right becomes highly effective in saving the investment costs and solving the agency problem. Thus, *P* has less incentive to use the strategic mechanism. Furthermore, if the probability of having non-contracted discoveries (β) is small and therefore strategic rights do not help extracting much rent from *E*, *P* would not adopt the strategic mechanism.

To summarize, the analysis implies that strategic rights and termination rights can be substitutes in mitigating agency problems. This will be empirically investigated in Section 5.

4. Data

We use the Thomson Reuters Recap Dataset (Recap), which contains a full list of all R&D alliance deals between pharmaceutical firms and bio-tech agents during 1974-2009. For most of the deals, the dataset only includes basic information (e.g., contracting parties, disease type, and stage of the R&D project involved). Within the above list, Recap provides contract details for 1,703 R&D agreements, which we use for the investigations.[24] We first clean this dataset by eliminating non-R&D

[24] According to the disclosure by Recap, for the agreements with details, at least one of the contracting parties was publicly listed in the contracting year. This data limitation can cause potential bias, since the size of the sampled client firms may be larger than the industry average. In an earlier version of this

agreements,[25] agreements involving more than three bio-tech agents,[26] and agreements with universities or non-profit organizations as agents. We also drop contracts signed before 1990, approximately 2.38% of the total sample.[27] The selection process results in 915 observations. We then read through all the agreements to identify the various strategic and termination rights.

For strategic rights, we refer to "most favored licensee/company," "right of first refusal," "right of first offer," "right of first discussion/consideration," and other similar rights which give clients an advantage when they compete with potential entrants over licenses for non-contracted discoveries. Appendix A provides a brief description of these rights. We create a dummy variable for the strategic rights: "*strategic right"* equals 1 if an agreement includes any strategic right and 0 otherwise. As summarized in Table 1, approximately 24% of the agreements include strategic rights.[28]

In the Recap dataset, all agreements grant clients termination rights, some with verifiable conditions and others without cause. Termination rights without cause provide stronger incentives for agents to devote effort than other termination rights. Thus, we focus on termination rights without cause: "*termination*" equals 1 if an agreement offers a termination right without cause to the client and 0 otherwise.[29] About 41.86% of the agreements include termination rights without cause.

Measures of Entry Threat

paper, we show that the main results stay robust after we control for client size (measured by total asset) and ROA (measured by net earnings divided by total asset), though it would significantly reduce the number of observations. Additionally, the activities of the sampled client firms might be more visible than that of the other firms, which, however, would not drive our empirical results.

[25] Recap classifies the nature of each agreement. If an agreement is classified as "R," "D," "CoD," and/or "CoL," it involves R&D activities by the agent. We also read all the contracts to verify their nature.

[26] Agreements with three or more agents have too much heterogeneity among the agents, and therefore, are eliminated. We keep a few agreements with two agents and take the average of the agents' characteristics.

[27] The main results stay robust when the data observations before 1990 are included.

[28] Various types of strategic rights may impose different degrees of binding power concerning the sales of non-contracted discoveries. In Section 5.2, we construct another measure of strategic rights based on their binding power. The empirical results are robust.

[29] It is difficult to subjectively evaluate the strength of various conditions associated with termination rights. Some conditional termination rights specify "cure periods", which allow agents to fix violations to the conditions before the termination rights are exercised. Intuitively, termination rights with cure periods are less stringent than those without cure periods. The main results stay robust when we incorporate two dummy variables on termination rights: "termination_2" equals 1 if an agreement contains the termination right without cause and 0 if otherwise; "termination_1 equals 1 if an agreement only contains a conditional termination right without any cure period and 0 if otherwise.

We are interested in how the level of potential entry threat affects firms' incentives to adopt strategic rights. One typical approach in the literature is to construct entry threat measures based on observations of historical entry. Unfortunately, such entry information is not available, as our paper focuses on entry threats from potential buyers of licenses for non-contracted R&D discoveries, but not on product market competition between clients and firms that have conducted relevant research and developed alternative drugs. Additionally, given our focus on the pharmaceutical industry, traditional entry measurements at the industry level do not work; rather, we must address potential entry threats at the disease level, given that R&D agreements normally target certain disease types.[30]

We use historical clinical trials by other pharmaceutical firms to proxy the potential entry threat at the disease level. Intuitively, firms with more experience in clinical trials for a certain disease type have an advantage in competing for licenses of discoveries of the same type. These firms also have more expertise in determining the potential value of discoveries of the same type. New firms or firms that try to change their business scopes can become entrants, but they are less competitive. Thus, if there have been more trials for a certain disease type, the entry threat for non-contracted discoveries of that type is larger.

Recap provides data on clinical trials, with disease types, that have been filed by pharmaceutical firms with the US Food and Drug Administration (FDA) since 1963. Based on this information, we construct the measures for entry threat. The Recap dataset classifies 21 disease types.[31] Because the disease classification might affect the market boundaries and potential entry threat, we check whether this classification is consistent with those employed by the World Health Organization (25 types

[30] In practice, some drugs have had their use changed to different disease types. However, non-contracted discoveries are more likely to be of the same disease type, given agents' expertise and the focus of scientific tests on certain disease types (see a related review by Ban (2006)). Klein (2008) also argues that cost-control measures have reduced the probability of finding discoveries with different disease types. The shift of a drug's use from one disease to another often occurs at the very late clinical trial stages or even in the product markets. In this paper, we focus on the R&D stages of drug developments and, therefore, conduct the analysis based on the disease type in the agreements.

[31] The disease types include allergic, autoimmune inflammatory, bone, cancer, cardiovascular, central nervous system, dental oral, dermatologic, endocrinological and metabolic, gastrointestinal, genitourinary gynecologic, hematologic, infectious-bacterial, infectious-miscellaneous, infectious-viral, ophthalmic, psychiatric, renal, respiratory, transplantation, and other miscellaneous.

classified)[32] and FDA (22 types classified).[33] More than 85% of the diseases classified by the three sources can be matched, suggesting the classification by Recap is standard.

Information about clinical trials in the very early years may not be complete. Moreover, for a particular client involved in a certain R&D project, clinical trials conducted by other pharmaceutical firms in more recent years can imply a larger entry threat than those in earlier years. To deal with such a data limitation and potential time trend, we take the following steps. First, we drop the contracts signed before 1990. Second, we construct the following entry threat measures by counting trials conducted by third parties within different-length time periods (10 years and 5 years) before clients and agents entered into the current agreements:[34]

For a particular agreement, "*entry threat (trials)*" (and "*entry threat 5 (trials)*) is the log value of 1 plus the number of other firms' clinical trials for the same disease type in the 10 years (and 5 years, respectively) before contracting.

For a particular agreement, "*entry threat (trial firms)*" (and "*entry threat 5 (trial firms)*) is the log value of 1 plus the number of other pharmaceutical firms that have conducted clinical trials for the same disease type in the 10 years (and 5 years, respectively) before contracting.

Since our empirical results stay robust under the above measures, in Section 5, we shall use "*Entry Threat (trials)*" as the main variable on entry threat.

Other Variables

We control several firm-specific and project-specific factors in the estimations. First, we consider equity links between clients and agents. As Filson and Morales (2006) show, many R&D agreements include equity links such that clients buy agents' equity stakes. The Recap dataset provides information on equity investments by clients in agents' firms as part of the upfront or continuing payments in R&D agreements. In theory, equity links can mitigate potential agency problems and therefore may interact with strategic rights. To address this possibility, we construct and control "*equity link*," which equals 1 if there are equity payments from the client and 0 otherwise.

[32] Source: http://apps.who.int/classifications/icd10/browse/2016/en
[33] Source: https://clinicaltrials.gov/ct2/search/browse?brwse=cond_cat
[34] Our empirical results stay robust with entry threat measures based on the trials in all previous years.

Previous cooperation can help clients obtain more information about agents' abilities and build up trust between them, thereby affecting contract design. Based on the full list of R&D deals provided by Recap, we construct "*previous relationship*" as the log value of 1 plus the number of projects jointly conducted by a client and an agent in the 10 years before they entered into the current agreement.[35]

The uncertainty level of R&D projects is often associated with the stages of drug development, which, in order of timing, include discovery, lead molecule, preclinical/formulation, Phase I, Phase II, Phase III trials, BLA/NDA filed, and approved. The first two stages typically face more uncertainty. Following Lerner and Malmendier (2010), we construct a variable "*early stage*" as a measure of uncertainty, which equals 1 if an agreement involves R&D activities in the discovery and/or lead molecule stages and 0 otherwise.[36] We also control "*project size* (in million USD)" provided in the Recap dataset.

We construct a variable "*Cancer_Cardio,*" which equals 1 if the agreement involves cancer or cardiovascular and 0 otherwise. Cancer and cardiovascular disease are the leading causes of death in the US, while the other diseases lead to significantly fewer death cases.[37] To capture potential disease fixed effects, it seems ideal to include 20 disease dummies into the estimations, which, however, would lead the p-value of the overall F-test for the whole regression to be larger than 10%, making the regression lose validity. One possible reason for this is that we build our entry threat measures at the disease level. That is, the entry threat is potentially a function of the disease type. Thus, the disease fixed effects may have been captured by the entry threat measures to some extent, and it can cause multicollinearity if we further add all disease dummies.

Since most of the agents are small and privately held, we do not have their financial information. Instead, we try to control agents' R&D experience and define "*agent R&D experience*" as the log value of 1 plus the number of R&D projects that the agent has conducted in the 10 years before the current agreement, based on the full list of R&D

[35] We have tried alternative constructions for "previous relationship" by referring to the number of joint projects by a client and an agent within the last five years and in all previous years. The results are robust.
[36] We have also tried estimations by including a dummy variable for every stage. Our main results stay robust under these alternative measures of uncertainty.
[37] Source: National Vital Statistics Report (http://www.cdc.gov/nchs/data/nvsr/nvsr61/nvsr61_04.pdf).

deals provided by Recap.[38] Additionally, we control "*agent listed,*" which equals 1 if the agent is publicly listed during the contracting year and 0 otherwise.

Government regulations for the pharmaceutical industry have changed over time. In the 1990s, implementation of the Prescription Drug User Fee Act and the Food and Drug Administration Modernization Act led to more registration requirements for clinical trials.[39] Also, in the early 2000s, more regulations and laws were implemented to emphasize the disclosure of trials.[40] To capture the possible effects from regulation changes and the corresponding time trends, we control a "timing" dummy, which equals 1 if an agreement is signed during 2000-2009 and 0 otherwise. Including year fixed effects would be one of the most straightforward ways to control for the effects from business cycles, industry trends, and other industry-specific events. However, when year dummies are included, the p-value of the overall F-test for the whole regression becomes larger than 10%. Thus, one limitation of this study is that we cannot rule out the potential effects from business cycles or industry trends.

Table 1 provides the summary statistics for all the variables. In this table, we report the absolute values. In the regression estimations, we convert the values of the variables "*entry threat (trials)", "agent R&D experience" and "previous relationship"* into log values.

(Insert Table 1 here)

5. Empirical Observations

In this section, we first present the main empirical observations regarding the adoption of strategic rights in R&D agreements, as well as the relationship between strategic rights and termination rights. Then we discuss the robustness of the results by using alternative measures of entry threat.

5.1 Entry Threat, Strategic Rights, and Termination Rights

The first two columns of Table 2 report the marginal effects in logit estimations with "*entry threat (trials)"* as the main entry threat measure and "*strategic right"* as

[38] We try alternative constructions for "agent R&D experience" by referring to the number of R&D projects that the agent has conducted in the last five years and in all previous years. The results are robust.
[39] Source: http://www.gpo.gov/fdsys/pkg/PLAW-105publ115/pdf/PLAW-105publ115.pdf#page=16
[40] Sources: https://www.clinicaltrials.gov/ct2/about-site/history#CongressPassesLawFDAMA and http://www.ortsedu.com/Guidance/FDA-Guidance-07.pdf

the dependent variable.[41] We control the project characteristics, including "*project size*," "early *stage*," "*equity link*," "*Cancer_Cardio*," the timing dummy, and agent characteristics.[42] The specification in Column 2 also controls "*termination*." However, in doing so, we do not suggest any causality between termination rights and strategic rights but only try to address their correlation. To capture the possibility that the uncertainty level of R&D projects may affect the relationship between strategic rights and terminations rights, we also include one interaction term, "*termination*early stage*."

No reverse causality problem exists in our estimations regarding the effects of entry threat on the use of strategic rights for two reasons. First, the entry threat measures are based on data from the years before a certain agreement is signed. Second, many R&D agreements are confidential and cannot be observed by other firms before entry.

The likelihood of having non-contracted discoveries varies among R&D projects. Also, the level of non-contractibility may affect both the adoption of strategic rights and the entry threat. However, this endogeneity problem is not relevant to our analysis. Our entry threat measures are based on other firms' trials in previous years, which should not be affected by the level of non-contractibility in the current projects. Additionally, market size at the disease level can affect our entry threat measures, but does not directly change firms' incentives to adopt strategic rights.[43]

(Insert Table 2 here)

The main results in Table 2 are consistent with the theoretical predictions from Section 3. In particular, the marginal effect of "*entry threat (trial)*" is positive and statistically significant, implying that a larger entry threat increases firms' incentives to adopt strategic rights regarding the future licensing of non-contracted discoveries. The result is similar under the alternative measures of entry threats, "*entry threat 5 (trials),*" *"entry threat (trial firms),*" and "*entry threat 5 (trial firms).*" As shown in Section 3, strategic contracts help contracting parties extract more rent from entrants and provide agents greater incentives to devote effort to contracted R&D activities, with both effects increasing in the level of the potential entry threat.

[41] We also verify the significance of the regression coefficients (available upon request).

[42] The main results stay robust after we control client size and profitability measured by ROA, though it would significantly reduce the number of observations. Since we do not observe any significant effect from client size and ROA, the main estimations do not control these two variables.

[43] All the strategic rights considered in this paper involve competition between clients and entrants over the licenses of non-contracted discoveries. Without any entry threat, theoretically, firms have no other motivation to use these strategic rights even when the potential market size is large.

Furthermore, the marginal effect of "*termination*" is negative and statistically significant. This result implies that strategic rights and termination rights tend to be substitutes in contract design, consistent with our theoretical analysis. Intuitively, both strategic rights and termination rights can motivate agents to put effort into contracted R&D activities instead of non-contracted activities, and therefore, they can be substitutes. [44] Studies on the interaction among contract terms have been limited. The literature mainly shows complementarity among certain contract terms. Our analysis complements the literature by providing evidence of a possible substitution relationship between the various contract rights.

Additionally, in Table 2, the marginal effect of "*termination*early stage*" is significantly negative, implying that, for R&D projects associated with the earlier stages of drug development, the substitution between termination rights and strategic rights becomes stronger. Intuitively, since the early stages of drug development face more uncertainty, clients are more likely to terminate projects upon observing negative signals about the projects' progress. Consequently, termination rights are more effective in motivating agents to place effort into contracted R&D activities. Thus, the potential benefits of using strategic rights to address agency problems becomes smaller.

5.2. Robustness Analysis

In this sub-section, we verify the robustness of the main empirical observations under some alternative measures of strategic rights and entry threat.

First, the various strategic rights may have different degrees of binding power concerning the licensing of non-contracted discoveries. For example, the most favored licensee, right of first refusal, and right of first offer clauses share a similar feature in that clients have priority in winning non-contracted discoveries in terms not less favorable than those offered to/by entrants, while the other strategic rights do not set such restrictions on selling terms. To capture this variation, we create an alternative measure, "*strategic right (ordered),*" which equals 2 if an agreement includes "most-favored licensee/company," "right of first refusal," or "right of first offer," 1 if it includes any other strategic right, and 0 if no strategic right is included. The empirical

[44] The substitution relationship can also be explained by the asymmetric information theory if agents with better abilities for contracted R&D activities have smaller chances of finding non-contracted discoveries. Agents with better abilities are more willing to accept termination rights, while smaller chances of finding non-contracted discoveries reduce firms' incentives to use strategic rights.

observations regarding the adoption of strategic rights as well as the relationship between strategic rights and termination rights stay robust with this alternative measure.

Second, we consider the alternative measures of entry threat based on other pharmaceutical firms' R&D or marketing projects by using the full list of R&D alliance deals provided by Recap:[45] for a particular agreement, "*entry threat (projects)*" (and "*entry threat 5 (projects)*) is the log value of 1 plus the number of other pharmaceutical firms' R&D or marketing projects for the same disease type in the 10 years (and 5 years, respectively) before contracting.

Intuitively, when the market size for one disease type is larger, more entrants will compete for the licensing rights of that type. If the above variables are significantly and positively correlated with the market size of the same disease type, they can serve as indirect entry threat measures.[46] We do not have sufficient data on market size at the disease level for the long term. Instead, we obtain the sales data of the top 200 branded and top 200 generic drugs between 2000 and 2010, as published by the *Newsmagazine for Pharmacists*. For each year, we calculate the total sales of those top-branded drugs for the same disease type as an imperfect proxy for market size. We find a positive and significant correlation between the total sales at the disease level and the number of projects of the same type conducted by other firms in the last 5 and 10 years. [47]

Columns 3 and 4 in Table 2 report the marginal effects of the estimations using "*entry threat (projects)*" as the measure on entry threat, with the main results staying robust.

To summarize, this section has identified two observations consistent with our theoretical analysis: contracting parties use strategic rights more often when the potential entry threat is larger; also, strategic rights and termination rights tend to be substitutes in R&D agreements.

6. Conclusion

[45] In theory, agents may try to include contract terms preventing clients from signing agreements with other agents for the same disease type, which would affect the construction of entry threat measures. However, we do not observe such contract terms in our dataset. Additionally, clients often sign agreements during different periods of time, and different projects for the same disease type may not compete directly with each other.

[46] The pharmaceutical firms that have conducted R&D or marketing projects for one disease type are more likely to enter and compete for discoveries of the same type (Allain, Henry, and Kyle, 2015).

[47] We obtain similar results when using the total sales of top generic drugs at the disease level and the total sales of both branded and generic drugs at the disease level as proxies for market size.

This paper examines firms' incentives for using strategic rights in R&D agreements. It provides important implications for contract design when contracts are incomplete and potential entry threat exists. Strategic rights not only allow the contracting parties to extract more rent from potential entrants, but they also motivate agents to put effort into contracted R&D activities by reducing agents' expected revenue from non-contracted R&D discoveries. Consequently, firms are more likely to use strategic rights when the likelihood of entry is larger. We further show that strategic rights and termination rights can be substitutes in mitigating agency problems.

Using a dataset of R&D agreements between pharmaceutical clients and bio-tech agents, we find empirical evidence consistent with the theoretical analysis. In particular, strategic rights are more likely to be adopted when potential entry threats are larger. We also find evidence of substitution between strategic rights and termination rights. This substitution relationship is stronger in projects involved in earlier R&D stages.

Our results are derived under some data limitations and strong assumptions. We construct the indirect entry threat measures at the disease level, given that we do not have sufficient information on historical entry. Also, to focus on the design of strategic contracts, in both the theoretical and empirical analysis, we ignore the possibility of mergers between clients and agents.[48] We also ignore equity links between clients and agents in the theoretical analysis, while equity links can potentially substitute strategic rights in mitigating agency problems. Future studies combining mergers, equity link, and contract design are desirable. Lastly, how different contract clauses interact with each other and the effects of contracting arrangements on innovation efficiency are also important but under-investigated areas.

[48] Mergers can prevent other firms from competing for the licenses of non-contracted discoveries. Possible reasons for firms adopting strategic contracts, instead of mergers, may include the high uncertainty level of R&D projects and the integration costs of mergers.

Appendix A: Descriptions of Various Strategic Rights

The following provides brief descriptions of various strategic rights adopted in the R&D agreements contained in the Recap dataset.

Most favored licensee/company: If the agent develops a non-contracted discovery, the client has priority in winning the discovery at the same licensing terms when competing with other potential licensees.

Right of first refusal: If the agent develops a non-contracted discovery and receives an offer from another potential licensee (i.e., the entrant), the agent must inform the client, who has the right to obtain the license by matching the outside offer. If the client matches the outside offer, there would be no further negotiation. If the client does not match the outside offer, the agent can accept the offer from the entrant.

Right of first offer: When a non-contracted discovery is found, the agent should first make an offer to the client (or the client should first make an offer to the agent), before searching for other potential licensees. If the client (or the agent) rejects the offer, the agent can look for other licensees, but cannot sell the license in more favorable terms than the offer extended to (or offered by) the initial client.

Right of first discussion/consideration: When a non-contracted discovery is found, the agent should first make an offer to the client (or the client should first make an offer to the agent), before searching for other potential licensees. If the client (or the agent) rejects the offer, the agent can look for other licensees. However, different from the right of first offer, these clauses do not impose restrictions on the licensing terms with other licenses.

Appendix B: Proofs of the Theoretical Results

Proof of Proposition 1:

First, if $\alpha > \alpha_0$, as shown in Lemma 1, in the benchmark case with standard auctions, *P* would make the investment while *A* obtains expected utility of $(\alpha + \beta)\theta R_0$. In contrast, as shown in the text, with ROFR, *A* obtains expected utility of $\beta\theta R_0$. That is, ROFR saves *P*'s agency cost by $\alpha\theta R_0$. Furthermore, ROFR increases the joint benefit for *P* and *A* from Project *NC* by $\beta\theta\Delta_{ROFR}$. Therefore, *P* offers a contract with ROFR if and only if the potential gain is larger than the extra contracting cost, i.e. $\beta\theta\Delta_{ROFR} + \alpha\theta R_0 > \delta$.

Second, if $\alpha \leq \alpha_0$, in the benchmark case with standard auctions, *P* would not make the investment and *A* obtains expected utility of $\beta\theta R_0$. As shown in the text, ROFR does not change *A*'s utility, but increases the joint benefit for *P* and *A* from Project *NC* by $\beta\theta\Delta_{ROFR}$. In addition, the net benefit from making the investment is $\alpha u - I$. Therefore, *P* offers a contract with ROFR if $\alpha u - I + \beta\theta\Delta_{ROFR} > \delta$.

To summarize, *P* makes the investment if and only $\alpha > \alpha_0$, or $\alpha \leq \alpha_0$ and $\alpha u - I + \beta\theta\Delta_{ROFR} - \delta > 0$. When making the investment, if $\alpha > \alpha_0$ and $\beta\theta\Delta_{ROFR} - \delta + \alpha\theta R_0 \leq 0$, *P* offers a royalty payment r_0 without ROFR; otherwise, *P* offers the contract with ROFR and a royalty payment r_{ROFR}.

Define $\theta_1, \theta_2, \theta_3$ such that $\alpha u - I - \alpha\theta_1 R_0 = 0$, $\beta\theta_2\Delta_{ROFR} + \alpha\theta_2 R_0 - \delta = 0$, $\alpha u - I + \beta\theta_3\Delta_{ROFR} - \delta = 0$. It is easy to verify that, $\alpha(\theta_1 - \theta_2)R_0 = \beta(\theta_2 - \theta_3)\Delta_{ROFR}$. Three scenarios are possible.

First, if $\theta_1 = \theta_2 = \theta_3$, define $\hat{\theta} = \min\{1, \theta_2\}$. For any $\theta > \hat{\theta}$, we have $\alpha = \frac{I}{u - \theta_1 R_0} < \alpha_0 \equiv \frac{I}{u - \theta R_0}$ and $\alpha u - I + \beta\theta\Delta_{ROFR} - \delta > 0$; for any $\theta \leq \hat{\theta}$, we have $\alpha \geq \alpha_0$ and $\beta\theta\Delta_{ROFR} + \alpha\theta R_0 - \delta \leq 0$. Therefore, if and only if $\theta > \hat{\theta}$, *P* would adopt ROFR.

Second, if $\theta_1 > \theta_2 > \theta_3$, define $\hat{\theta} = \min\{1, \theta_2\}$. For any $\theta \geq \theta_1$, we have $\alpha = \frac{I}{u - \theta_1 R_0} \leq \alpha_0 \equiv \frac{I}{u - \theta R_0}$ and $\alpha u - I + \beta\theta\Delta_{ROFR} - \delta > 0$; for any $\theta \in (\hat{\theta}, \theta_1)$, we have $\alpha > \alpha_0$ and $\beta\theta\Delta_{ROFR} + \alpha\theta R_0 - \delta > 0$; for any $\theta \leq \hat{\theta}$, we have $\alpha > \alpha_0$ and $\beta\theta\Delta_{ROFR} + \alpha\theta R_0 - \delta \leq 0$. Therefore, if and only if $\theta > \hat{\theta}$, *P* would adopt ROFR.

Third, if $\theta_1 < \theta_2 < \theta_3$, define $\hat{\theta} = \min\{1, \theta_3\}$. For any $\theta > \hat{\theta}$, we have $\alpha < \alpha_0$ and $\alpha u - I + \beta\theta\Delta_{ROFR} - \delta > 0$; for any $\theta \in [\theta_1, \hat{\theta}]$, we have $\alpha \leq \alpha_0$ and $\alpha u - I + \beta\theta\Delta_{ROFR} - \delta \leq 0$; for $\theta < \theta_1$, we have $\alpha > \alpha_0$ and $\beta\theta\Delta_{ROFR} + \alpha\theta R_0 - \delta < 0$. Therefore, if and only if $\theta > \hat{\theta}$, *P* would adopt ROFR. Q.E.D.

Proof of Lemma 2:

The proof is similar to the analysis in Hua (2007) and therefore we only provide a sketch here. As shown in the text, to motivate *A* to put effort in Project *C*, the royalty payment should satisfy $r^* \geq \theta R_1$. Without loss of generality, suppose that *P* chooses $r^* = \theta R_1$. The ex-ante IR constraint must be binding; otherwise *P* can always increase his utility by reducing $T_P(v)$ (and R_1) for all v by a small amount. Therefore, we have $(\alpha + \beta)\theta R_1 = \beta\theta R_0$.

Applying the standard mechanism design approach to the IC and IR constraints, we can show that, under the optimal mechanism, for $i = P, E$, $Q_i^*(v)$ is non-decreasing in v and $T_i^*(v) = Q_i^*(v)v - \int_{\underline{v}}^{\overline{v}} Q_i^*(x)dx - V_i(\underline{v})$, where $V_i(\underline{v})$ is $i's$ expected ex-post

utility when his value is $\underline{v}$. The optimal mechanism should set $V_E(\underline{v}) = 0$. In contrast, to ensure that the ex-ante IR constraint is binding, we need to choose $V_P(\underline{v}) \geq 0$ such that $(\alpha + \beta)\theta R_1 = \beta\theta R_0$.

Given the binding ex-ante IR constraint, the objective function can be re-written as

$$Max_{(r,Q_i,T_i)}\beta\left\{(1-\theta)\int_{\underline{v}}^{\overline{v}} v_P dF(v_P) + \theta[\int_{\underline{v}}^{\overline{v}} Q_P(v_P)v_P dF(v_P) + \int_{\underline{v}}^{\overline{v}}[Q_E(v_E)v_E - \int_{\underline{v}}^{\overline{v}} Q_E(x)dx]dF(v_E)]\right\} + \alpha u - I - \delta$$

Integrating the above objective function by parts, and then substituting $Q_P(v_P) \equiv E_{v_E}[q_P(v_P, v_E)]$, $Q_E(v_E) \equiv E_{v_P}[q_E(v_P, v_E)]$, the optimization problem becomes:

$$Max_{(q_i)}\beta(1-\theta)\int_{\underline{v}}^{\overline{v}} v_P dF(v_P) + \alpha u - I - \delta$$

$$+\beta\theta\int_{\underline{v}}^{\overline{v}}\int_{\underline{v}}^{\overline{v}}\left\{[v_P]q_P(v_P, v_E) + \left[v_E - \frac{1-F(v_E)}{f(v_E)}\right]q_E(v_P, v_E)\right\}dF(v_P)dF(v_E)$$

Subject to: $Q_i(v_i)$ is non-decreasing in v_i, for $i = P, E$.

Maximizing the above problem point-wise, we have the optimal strategic mechanism: if v_P is greater than $v_E - (1 - F(v_E))/f(v_E)$, P wins the license; otherwise, E wins. Accordingly, $Q_i^*(v_i)$ is non-decreasing in v_i, for $i = P, E$, given $(1 - F(v))/f(v)$ decreasing in v. Also, it is easy to verify that $z = V_P(\underline{v}) \geq 0$ exists such that $(\alpha + \beta)\theta R_1 = \beta\theta R_0$. Given this mechanism, if a non-contracted discovery is found and *E* enters, the joint benefit for *P* and *A* from the non-contracted discovery is

$$\int_{\underline{v}}^{\overline{v}} Q_P^*(v_P)v_P dF(v_P) + \int_{\underline{v}}^{\overline{v}} T_E^*(v_E)dF(v_E)\}$$

$$= \int_{\underline{v}}^{\overline{v}}\int_{\underline{v}}^{\overline{v}}\left\{[v_P]q_P(v_P, v_E) + \left[v_E - \frac{1-F(v_E)}{f(v_E)}\right]q_E(v_P, v_E)\right\}dF(v_P)dF(v_E),$$

which is higher than their joint benefit under the standard auctions, $\int_{\underline{v}}^{\overline{v}} v_P dF(v_P)$. Therefore, we have

$$\Delta = \int_{\underline{v}}^{\overline{v}} Q_P^*(v_P)v_P dF(v_P) + \int_{\underline{v}}^{\overline{v}} T_E^*(v_E)dF(v_E)\} - \int_{\underline{v}}^{\overline{v}} v_P dF(v_P) > 0.$$

Now consider two scenarios. First, if $\alpha > \alpha_0$, as shown in Lemma 1, in the benchmark case with standard auctions, *P* would make the investment while *A* obtains an expected utility of $(\alpha + \beta)\theta R_0$. In contrast, under the above strategic mechanism, *A* obtains an expected utility of $\beta\theta R_0$. That is, the strategic mechanism saves *P*'s agency cost by $\alpha\theta R_0$. Furthermore, this mechanism increases the joint benefit for *P* and *A* from Project *NC* by $\beta\theta\Delta$. Therefore, *P* offers a contract with the optimal strategic mechanism if and only if $\beta\theta\Delta + \alpha\theta R_0 > \delta$.

Second, if $\alpha \leq \alpha_0$, in the benchmark case with standard auctions, *P* would not make the investment and *A* obtains expected utility of $\beta\theta R_0$. The optimal strategic mechanism does not change *A*'s utility, but increases the joint benefit for *P* and *A* from

Project *NC* by $\beta\theta\Delta$. In addition, the net benefit from making the investment is $\alpha u - I$. Therefore, *P* makes the investment and adopts the optimal strategic mechanism if and only if $\alpha u - I + \beta\theta\Delta > \delta$. Q.E.D.

Proof of Proposition 2:

The proof is similar to that of Proposition 1 and we only provide a sketch here. Define $\theta_1', \theta_2', \theta_3'$ such that $\alpha u - I - \alpha\theta_1' R_0 = 0$, $\beta\theta_2'\Delta + \alpha\theta_2' R_0 - \delta = 0$, $\alpha u - I + \beta\theta_3'\Delta - \delta = 0$. Note that, $\alpha(\theta_1' - \theta_2')R_0 = \beta(\theta_2' - \theta_3')\Delta$. Three scenarios are possible.

First, if $\theta_1' = \theta_2' = \theta_3'$, define $\tilde{\theta} = \min\{1, \theta_2'\}$. For any $\theta > \tilde{\theta}$, we have $\alpha = \frac{I}{u - \theta_1 R_0} < \alpha_0$ and $\alpha u - I + \beta\theta\Delta - \delta > 0$; for any $\theta \leq \tilde{\theta}$, we have $\alpha \geq \alpha_0$ and $\beta\theta\Delta + \alpha\theta R_0 - \delta \leq 0$. Lemma 2 then implies that, if and only if $\theta > \tilde{\theta}$, *P* would adopt the optimal strategic mechanism.

Second, if $\theta_1' > \theta_2' > \theta_3'$, define $\tilde{\theta} = \min\{1, \theta_2'\}$. Similar to the analysis in Proposition 1, Lemma 2 implies that, if and only if $\theta > \tilde{\theta}$, *P* would adopt the optimal strategic mechanism.

Third, if $\theta_1' < \theta_2' < \theta_3'$, define $\tilde{\theta} = \min\{1, \theta_3'\}$. Similar to the analysis in Proposition 1, Lemma 2 implies that, if and only if $\theta > \tilde{\theta}$, *P* would adopt the optimal strategic mechanism. Q.E.D.

Proof of Proposition 3:

Suppose that $\alpha > \alpha_0$ and $\beta\theta\Delta + \alpha\theta R_0 - \delta > 0$, or $\alpha \leq \alpha_0$ and $\alpha u - I + \beta\theta\Delta - \delta > 0$. Under the contract with a royalty payment $r_T = (1-\phi)\theta R_0$ and the termination right, the joint benefit for *P* and *A* from Project *C* is $\alpha u - I + (1-\alpha)\phi w - \delta$. Since the termination right does not change *P*'s benefit from non-contracted discoveries, he would make the investment as long as his expected utility from the contracted discovery, $\alpha(u - r_T) - I + (1-\alpha)\phi w - \delta$, is positive.

If *P* only adopts the optimal strategic mechanism as specified in Lemma 2 but not the termination right, his utility is

$$A1 = (\alpha u - I) + \beta\theta\Delta + \beta\int_{\underline{v}}^{\overline{v}} v_P dF(v_P) - \beta\theta R_0 - \delta.$$

If *P* only adopts the termination right, given r_T, his utility is

$$A2 = (\alpha u - I) + \beta\int_{\underline{v}}^{\overline{v}} v_P dF(v_P) + (1-\alpha)\phi w - (\alpha(1-\phi) + \beta)\theta R_0 - \delta.$$

If *P* adopts both the strategic mechanism and the termination right, his utility can be written as

$$A3 = (\alpha u - I) + \beta\theta\Delta + \beta\int_{\underline{v}}^{\overline{v}} v_P dF(v_P) + (1-\alpha)\phi w - \beta\theta R_0 - 2\delta.$$

When $\phi = 0$, obviously, *P* and *A* would not adopt the termination right. According to Lemma 2, *P* and *A* would adopt the optimal strategic mechanism. By continuity, there exists $\phi_L > 0$ such that when $\phi \leq \phi_L$, *P* and *A* adopt the strategic mechanism but not the termination right.

When $\phi = 1$, given the assumption $(1-\alpha)w - \delta > 0$, $A3$ is strictly larger than $A1$. Define $\hat{\beta}$ such that $\hat{\beta}\theta\Delta - \delta = 0$. For $\phi = 1$ and $\beta < \hat{\beta}$, $A2$ is strictly larger than $A3$. By continuity, there exists a cut-off $\phi_H < 1$ such that, as long as $\phi \geq \phi_H$ and $\beta < \hat{\beta}$, *P* and *A* adopt the termination right but not the strategic mechanism. Q.E.D.

Appendix C: Robustness with the Ex-ante Observable Value

Our main model in Section 2 assumes that *P* observes his value v_P of a non-contracted discovery only after the discovery is developed. The main insights, however, are robust under the alternative framework where *P* observes v_P before contracting. For illustration, suppose that $v_P \in [0,1]$ is observed by both *P* and *A* at Date 1. At Date 4, upon entry, *E* privately observes his value, v_E, which is drawn from the uniform distribution on [0,1]. We further assume that $u > 1$ and ϕ=0.

As a benchmark, suppose that the licensing of non-contracted discoveries follows the standard auction. Similar to the analysis in Section 3, we can show that the expected joint benefit for *P* and *A* from non-contracted discoveries is βv_P, while *A*'s revenue from non-contracted discoveries is $\beta\theta[\int_0^{v_P} v_E dv_E + \int_{v_P}^1 v_P dv_E] = \beta\theta(v_P - \frac{v_P^2}{2})$.

In this benchmark case, given the royalty payment r, *A* would put effort into Project *C* if and only if

$$\alpha r + \beta\theta(v_P - \tfrac{v_P^2}{2}) \geq (\alpha + \beta)\theta(v_P - \tfrac{v_P^2}{2}),$$

or, equivalently, $r \geq \theta(v_P - \frac{v_P^2}{2})$. Thus, *P* would offer a royalty payment $r_0 = \theta(v_P - \frac{v_P^2}{2})$. *P*'s expected utility from Project *C* is $\alpha(u - r_0) - I$, which is positive if and only if $\alpha > \alpha_0 \equiv \frac{I}{u - \theta\left(v_P - \frac{v_P^2}{2}\right)}$. To summarize, *P* would make the investment and offer a royalty payment of r_0 if and only if $\alpha > \alpha_0$.

Now suppose that the R&D contract can include a strategic right for the licensing of non-contracted discoveries. It is easy to show that the optimal contract for *P* would specify the following mechanism: For any non-contracted discovery, *A* should first offer a price of $\frac{1+v_P}{2}$ to *E*; if *E* accepts, *A* would transfer $\frac{1+v_P}{2}$ to *P* as a break-up fee, and if *E* declines, *P* would obtain the license with zero payment.

With the above mechanism, *A* does not receive any revenue from non-contracted discoveries and would put effort into Project *C* given any positive royalty.

Furthermore, *A* would accept the contract with the above mechanism as long as

$$\alpha r + \beta * 0 \geq \beta\theta\left(v_P - \frac{v_P^2}{2}\right).$$

Thus, the lowest royalty payment is $r = \frac{\beta}{\alpha}\theta\left(v_P - \frac{v_P^2}{2}\right)$. It can be verified that, given this royalty payment and the above strategic mechanism, *P*'s expected utility is

$$(\alpha u - I) + \beta[(1-\theta)v_p + \theta\tfrac{(1+v_P)^2}{4}] - \beta\theta\left(v_P - \tfrac{v_P^2}{2}\right) - \delta.$$

Similar to the analysis in Section 3, the above mechanism have two effects. First, this mechanism helps extracting more rent from *E*: The joint benefit for *P* and *A* from non-contracted discoveries is $\beta[(1-\theta)v_p + \theta\frac{(1+v_P)^2}{4}]$, larger than that in the benchmark case (βv_P). Second, it mitigates the agency problem and reduces *P*'s agency cost by $\alpha\theta\left(v_P - \frac{v_P^2}{2}\right)$. Both effects would encourage *P* to make the investment. In particular, when $\alpha < \alpha_0$, in the benchmark case with the standard auctions *P* would not make the investment, whereas the strategic mechanism restores *P*'s investment incentives.

Appendix D: Summary Statistics and Empirical Results

Table 1 Summary Statistics

Discrete Variables		Obs	0	1	2		
	Strategic Right	915	695	220			
	Termination	915	532	383			
	Agent Listed	915	284	631			
	Cancer_Cardio	915	601	314			
	Early Stage	898	444	454			
	Equity Link	915	538	377			
	Timing	915	664	251			
Continuous Variables		Obs	Mean	Std Dev	Min	Max	Skewness
	Entry Threat (trials)	915	98.92	139.71	0	701	1.97
	Entry Threat (projects)	915	332.15	435.84	0	3001	2.39
	Previous Relationship	915	0.18	0.62	0	6	4.45
	Agent R&D Experience	915	7.2	8.6	0	59	1.95
	Project Size (in million USD)	843	100	160.54	0	953	2.63

Note: We report the level for each variable in this table, while we use log values for "entry threat (trials)", "entry threat (projects)", "R&D experience" and "previous relationship" in the regression models. "Timing" equals 1 if an agreement is signed during 2000-2009 and 0 otherwise.

Table 2 Entry Threat, Strategic Right and Termination Right (Marginal Effects Reported)

	Strategic Right	Strategic Right	Strategic Right	Strategic Right
Entry Threat (trials)	0.020	0.027		
	(1.65)*	(2.25)**		
Entry Threat (projects)			0.033	0.038
			(2.97)***	(3.55)***
Project Size	173.976	167.265	143.517	134.922
	(1.52)	(1.49)	(1.25)	(1.20)
Cancer_Cardio	-0.044	-0.061	-0.06	-0.073
	(1.15)	(1.64)	(1.75)	(2.20)**
Agent Listed	-0.046	-0.035	-0.05	-0.041
	(1.30)	(1.04)	(1.43)	(1.19)
Early Stage	-0.047	-0.019	-0.039	-0.011
	(1.49)	(0.51)	(1.25)	(0.29)
Previous Relationship	0.021	0.011	0.022	0.011
	(0.41)	(0.22)	(0.42)	(0.22)
Agent R&D Experience	-0.021	-0.024	-0.021	-0.024
	(1.34)	(1.6)	(1.31)	(1.56)
Equity Link	0.018	0.022	0.019	0.023
	(0.59)	(0.71)	(0.61)	(0.76)
Termination		-0.107		-0.109
		(2.78)***		(2.86)***
Termination*Early Stage		-0.12		-0.122
		(2.43)**		(2.51)**
Timing	Controlled	Controlled	Controlled	Controlled
N	826	826	826	826
Pseudo R-sq	0.016	0.05	0.023	0.059
Chi^2	14.41	46.11	21.04	54.47

Note: Values in parentheses are t-statistics; ***: 1% significance; **: 5% significance; *: 10% significance.

References

Admati, Anat R., and Paul Pfleiderer. “Robust Financial Contracting and the Role of Venture Capitalists.” *The Journal of Finance* Vol. 49, (1994), pp. 371-402.

Aghion, Philippe and Patrick Bolton, “Contracts as a Barrier to Entry,” *American Economic Review* Vol. 77 (1987), pp. 388-401.

Allain, Marie-Laure, Emeric Henry, and Margaret Kyle, "Competition and the Efficiency of Markets for Technology," *Management Science,* Vol. 62 (2015), pp.1000-1019.

Anand, Bharat and Tarun Khanna, “The Structure of Licensing Contracts,” *Journal of Industrial Economics*, Vol. 48 (2000), pp. 103-135.

Arrunada, Benito, Luis Garicano, and Luis Vazquez, “Contractual Allocation of Decision Rights and Incentives: The Case of Automobile Distribution,” *Journal of Law, Economics, and Organization,* Vol. 17 (2001), pp. 257-284.

Ban, Thomas, “The Role of Serendipity in Drug Discovery,” *Dialogues in Clinical Neuroscience,* Vol. 8 (2006), pp. 335-344.

Bergemann, Dirk and Ulrich Hege, “Venture Capital Financing, Moral Hazard, and Learning,” *Journal of Finance,* Vol. 22 (1998), pp. 703-735.

Bikhchandani, Sushil, Steven A. Lippman, and Reade Ryan, “On the Right-of-First-Refusal,” *BE Journals of Theoretical Economics: Advances in Theoretical Economics*, Vol.5 (2005), Article 4.

Brickley, James A. and Frederick H. Dark, “The Choice of Organizational Form: The Case of Franchising,” *Journal of Financial Economics*, Vol. 18 (1987), pp. 401-420.

Brickley, James A., “Incentive Conflicts and Contractual Restraints: Evidence from Franchising,” *Journal of Law and Economics*, Vol. 42 (1999), pp. 745-774.

Butz, David A, “Durable Goods Monopoly and Best-Price Provisions,” *American Economic Review,* Vol. 80 (1990), pp. 1062-1076.

Caves, Richard E., Harold Crookell, and J. Peter Killing, “The Imperfect Market for Technology Licenses,” *Oxford Bulletin of Economics and Statistics*, Vol. 45 (1983), pp. 249-268.

Che, Yeon-Koo and Tai-Yeong Chung, “Contract Damages and Cooperative Investments,” *Rand Journal of Economics*, Vol. 30 (1999), pp. 84-105.

Che, Yeon-Koo and Donald B. Hausch, “Cooperative Investments and the Value of Contracting,” *American Economic Review*, Vol. 89 (1999), pp. 125-147.

Che, Yeon-Koo and Tracy R. Lewis, "The Role of Lockups in Takeover Contests," *Rand Journal of Economics*, Vol. 38 (2007), pp. 648-669.

Choi, Albert, "A Rent Extraction Theory of the Right of First Refusal," *Journal of Industrial Economics*, Vol. 57 (2009), pp. 252-262.

Chung, Tai-Yeong, "Incomplete Contracts, Specific Investments, and Risk Sharing," *Review of Economic Studies*, Vol. 58 (1991), pp. 1031-1042.

Cooper, T. and T. L. Fries, "The Most Favored Nation Pricing Policy and Negotiated Prices," *International Journal of Industrial Organization* (1991).

Crama, Pascale, Bert De Reyck and Niyazi Taneri, "Licensing Contracts: Control Rights, Options, and Timing," *Management Science*, published online (2016).

Crocker, Keith J. and Thomas P. Lyon, "What Do 'Facilitating Practices' Facilitate? An Empirical Investigation of Most-Favored-Nation Clauses in Natural Gas Contracts," *Journal of Law and Economics*, Vol. 37 (1994), pp. 297-322.

Daughety, Andrew and Jennifer Reinganum, "Exploiting Future Settlements: A Signaling Model of Most-Favored-Nation Clauses in Settlement Bargaining," *Rand Journal of Economics*, Vol.35 (2004), pp. 467-485.

Dutta, Shantanu, Jan B. Heide, and Mark E. Bergen, "Vertical Territorial Restrictions and Public Policy: Theories and Industry Evidence," *Journal of Marketing*, Vol. 63 (1999), pp. 121-137.

Elfenbein, Daniel W. and Josh Lerner, "Ownership and Control Rights in Internet Portal Alliances, 1995-1999," *Rand Journal of Economics*, Vol. 34(2003), pp. 356-369.

Elfenbein, Daniel W. and Josh Lerner, "Contractual Incompleteness, Contingent Control Rights, and the Design of Internal Portal Alliances," *Journal of Law, Economics and Organization*, forthcoming.

Filson, Darren, and Rosa Morales, "Equity Links and Information Acquisition in Biotechnology Alliances," *Journal of Economic Behavior and Organization*, Vol. 59 (2006), pp. 1-28.

Gil, Ricard and Francine Lafontaine, "Using Revenue Sharing to Implement Flexible Pricing: Evidence from Movie Exhibition Contracts," *Journal of Industrial Economics*, Vol. 60 (2012), pp. 187-219.

Grosskopf, Brit and Alvin E. Roth, "If You are Offered the Right of First Refusal, Should You Accept? An Investigation of Contract Design," *Games and Economic Behavior*, Vol. 65 (2009), pp. 176-204.

Heide, Jan. B, Shantanu Dutta, and Mark Bergen, "Exclusive Dealing and Business Efficiency: Evidence from Industry Practice," *Journal of Law and Economics*, Vol. 41 (1998), pp. 387-407.

Hua, Xinyu, "Strategic Ex-ante Contracts: Rent Extraction and Opportunity Costs," *Rand Journal of Economics,* Vol. 38 (2007), pp. 786-803.

--, "The Right of First Offer," *International Journal of Industrial Organization*, Vol. 30 (2012), pp.389-397.

Hueth, Brent, Ethan Ligon, and Tigran Melkonyan, "Interactions between Explicit and Implicit Contracts: Evidence from California Agriculture," Mimeo, University of Wisconsin, Madison (2008).

Kaplan, Steven N and Per Strömberg, "Financial Contracting Theory Meets the Real World: An Empirical Analysis of Venture Capital Contracts," *Review of Economics Studies*, Vol. 70 (2003), pp. 281-315.

Klein, Donald, "The Loss of Serendipity in Psychopharmacology," *Journal of the American Medical Association,* Vol. 299 (2008), pp. 1063-1065.

Lafontaine, Francine, "Agency Theory and Franchising: Some Empirical Results," *Rand Journal of Economics*, Vol. 23 (1992), pp. 263-283.

Lafontaine, Francine, "Contractual Arrangements as Signaling Devices: Evidence from Franchising," *Journal of Law, Economics, and Organization,* Vol. 9 (1993), pp. 256-289.

Lafontaine, Francine, and Emmanuel Raynaud, "Residual Claims and Self Enforcement as Incentive Mechanisms in Franchise Contracts: Substitutes or Complements?" *The Economics of Contracts in Prospect and Retrospect,* (Cambridge University Press, 2002).

Lafontaine, Francine, and Margaret Slade, "Inter-firm Contracts: Evidence" in *Handbook of Organizational Economics,* (The Princeton University Press, 2012).

Lerner, Josh and Ulrike Malmendier, "Contractibility and Contract Design in Strategic Alliances," *American Economic Review,* Vol. 100 (2010), pp. 214-246.

Lerner, Josh and Robert P. Merges, "The Control of Strategic Alliance: An Empirical Analysis of Biotechnology Collaborations," *Journal of Industrial Economics*, Vol. 46 (1998), pp. 125-156.

Lerner, Josh and Antoinette Schoar, "Does Legal Enforcement Affect Financial Transactions? The Contractual Channel in Private Equity," *Quarterly Journal of Economics*, Vol. 120 (2005), pp. 223-246.

Marvel, Howard P., "Exclusive Dealing," *Journal of Law and Economics*, Vol. 25 (1982), pp. 1-25.

Matouschek, Niko and Paolo Ramezzana, "The Role of Exclusive Contracts in Facilitating Market Transactions," *Journal of Industrial Economics*, Vol. 55 (2007), pp. 197-222.

Neher, Darwin V., "Staged Financing: An Agency Perspective," *Review of Economic Studies*, Vol. 66 (1999), pp. 255-274.

Rogerson, William P., "Efficient Reliance and Damage Measures for Breach of Contracts," *Rand Journal of Economics*, Vol. 26 (1984), pp. 39-53.

--, "Contractual Solutions to Hold-up Problems," *Review of Economic Studies*, Vol. 59 (1992), pp. 777-793.

Ryall, Michael D. and Rachelle C. Sampson, "Formal Contracts in the Presence of Relational Enforcement Mechanisms: Evidence from Technology Development Projects," *Management Science*, Vol. 55 (2009), pp. 906-925.

Segal, Ilya R. and Michael D. Whinston, "Exclusive Contracts and Protection of Investment," *Rand Journal of Economics*, Vol. 31 (2000), pp. 603-633.

Spier, Kathryn E. and Michael D. Whinston, "On the Efficiency of Privately Stipulated Damages for Breach of Contract: Entry Barriers, Reliance, and Renegotiation," *Rand Journal of Economics*, Vol. 26 (1995), pp. 180-202.

Susarla, Anjana, "Contractual flexibility, rent seeking, and renegotiation design: An empirical analysis of information technology outsourcing contracts," *Management Science*, Vol. *58* (2012), pp. 1388-1407.

Zanarone, Giorgio, "Vertical Restraints and the Law: Evidence from Automobile Franchising," *Journal of Law and Economics*, Vol. 52 (2009), pp. 691-700.