

The impact of inter-firm relationships on the allocation of control rights in bio-pharmaceutical alliances

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Abstract

In this paper, I examined the impact of inter-firm relationships on the allocation of control rights in bio-pharmaceutical alliances. The relational factors examined include (1) prior alliance experience between the biotech and the pharmaceutical firms; (2) future collaborative opportunities based on biotech's business strategy; and (3) inter-firm rivalry between the biotech and the pharmaceutical firms. The results show that biotech firms are likely to receive more control rights in drug development and commercialization, if they have prior collaboration with their partners or if they adopt a product development strategy rather than a technology service strategy. In contrast, if biotech firms have competing products or technologies with their partners, they will receive fewer control rights. The relational effect is stronger in early-stage research than in late-stage development. The results suggest that relational factors have strong impact on the allocation of control rights, especially when there are high risks of transactional hazards.

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Introduction

In collaborative innovation, ownership of the innovation is often split into different control rights between the allying parties. Such control rights include not only the development and commercialization of the innovation, but also the exploitation of related intellectual properties (Lerner & Merges, 1998). Unlike monetary rewards, control rights allow firms to make decisions and take residual claims of the underlying assets (Grossman & Hart, 1986). As the decisions are often inter-related, firms typically seek a number of control rights rather than any singular right in collaborative innovation. The potential value of control rights can be substantial. In the biopharmaceutical industry, worldwide exclusive control of a blockbuster drug reaches over \$1 billion on annual sales alone, not to mention licensing fee and other paybacks. It is argued that firms with strong control of the innovation are entitled to appropriate from late-stage development and commercialization, which incentivise them to invest in early-stage drug development (Aghion & Tirole, 1994). The allocation of control rights, therefore, becomes important in alliance contract, as it affects not only the value appropriation but also the value creation in collaborative innovation.

Prior literature has examined the allocation of control rights in collaborative innovation from two different perspectives, namely the incentive design and the bargaining power (Aghion & Tirole, 1994; Lerner & Merges, 1998). Property rights theorists argue that control rights can be taken as incentive mechanisms to elicit

efforts from the allying parties, and firms with greater marginal contribution should be awarded with more control rights to avoid under-investment in collaborative innovation (Aghion & Tirole, 1994). However, such an allocation may not be realized under the influence of bargaining power. Previous research on bio-pharmaceutical alliances shows that entrepreneurial biotech firms, on average, receive fewer control rights than established pharmaceutical firms in drug development and commercialization. The situation is worse for biotech firms when they are under financial stress, and when the collaboration is in early-stage drug discovery (Lerner & Merges, 1998; Lerner, Shane & Tsai, 2003; Higgins, 2007). The results suggest that bargaining power has strong impact on the allocation of control rights, which may overweigh the concerns of incentive design in bio-pharmaceutical alliances.

Although previous research has identified important factors in the allocation of control rights, such as firm's marginal contribution and their bargaining power, much of the discussion is based on individual transactions, which does not take inter-firm relationships into consideration (Aghion & Tirole, 1994; Lerner & Merges, 1998; Lerner, Shane & Tsai, 2003; Higgins 2007). The importance of the inter-firm relationship has been emphasized in the alliance literature on various occasions, including partner selection, governance forms, contract development, and alliance performance, which focuses on the effect of trust and learning in repeated collaboration (Gulati, 1995a; Hoetker, 2005; Dyer & Singh, 1998; Reuer & Arino, 2007; Ryall & Sampson, 2006). The relational theories suggest that the development of trust relieves the concerns of opportunistic behaviours, and shifts the attention from private gains to joint benefits, which may prevent the over-exploitation of firm's bargaining power. In addition, the knowledge about partner's competences, intentions

and behaviours through prior interactions allows firms to better understand partner's potential contribution in future collaboration. By overlooking the relational mechanisms in the allocation of control rights, previous studies neglect the dynamics that influence firm's use of bargaining power and their assessment of partner's potential contribution in repeated collaboration.

In this paper, I examined the impact of inter-firm relationships on the allocation of control rights in bio-pharmaceutical alliances. The relational factors examined include (1) prior alliance experience between the biotech and the pharmaceutical firms; (2) future collaboration based on biotech's business strategy; and (3) inter-firm rivalry between the biotech and the pharmaceutical firms. The results show that biotech firms are likely to receive more control rights in drug development and commercialization, if they have prior collaboration with their partners or if they adopt a product development strategy rather than a technology service strategy. In contrast, if biotech firms have competing products or technologies with their partners, they will receive fewer control rights. The relational effect is stronger in early-stage research than in late-stage development. The results suggest that relational factors have strong impact on the allocation of control rights, especially when there are high risks of transactional hazards.

The Allocation of Control Rights: A Relational Perspective

Previous research suggests that a key problem in the allocation of control rights is that firm's bargaining power may not match with their marginal contribution in collaborative innovation, and firms with strong bargaining power may seek control for

value appropriation and neglect the incentive concerns for value creation (Aghion & Tirole, 1994). In empirical studies, researchers have examined the impact of firm's marginal contribution and their bargaining power on the allocation of control rights in individual alliances. The marginal contribution in collaborative innovation is associated with the nature of the task and firm's research capabilities, and the bargaining power is related to research firm's access to funding and funding firm's access to alternative technologies (Lerner & Merges, 1998; Lerner, Shane & Tsai, 2003; Elfenbein & Lerner, 2003; Higgins, 2007). The approach taken has been largely static, which focuses on the relative importance of firm's marginal contribution and their bargaining power in each single transaction. However, firms do not limit themselves to one-off transactions, and may interact with their partners repeatedly over time. The development of inter-firm relationships may influence firm's use of bargaining power and their assessment of partner's potential contribution, which will shift the allocation of control rights.

Inter-firm relationships are shaped by both cooperative and competitive forces. Previous research on cooperative relationships has focused mainly on prior alliance experience and future collaboration expectations (Gulati, 1995a; Poppo & Zenger, 2002; Baker, Gibbons, & Murphy, 2002). On the one hand, firms learn about their partner's competences and intentions, and develop mutual trust through prior collaboration (Gulati, 1995a). On the other hand, firms will shift their attention from short-term private gains to long-term collective benefits in expectation of future collaboration, and behave cooperatively for social and economic reasons (Granovetter, 1985; Uzzi, 1997; Baker, Gibbons, & Murphy, 2002). The relational mechanisms in repeated collaboration relieve the concerns of transactional hazards, deepen the

understanding of partner's contribution, and prevent firms from overly exploiting their bargaining power in the allocation of control rights. In contrast, competition between the allying parties tightens the relationship in collaborative innovation. Previous research suggests that inter-firm rivalry increases the risks of opportunistic behaviours and highlights the concerns of transactional hazards in alliances (Das & Teng, 2000; Park & Ungson, 2001). To safeguard themselves, firms are likely to choose equity-based governance form and internalize the control rights in alliances.

Prior Collaboration

As Gulati (1995a) has pointed out, prior interactions breed trust between the allying parties. Trust has different connotations in the literature, which may refer to the expectations of trustee's competences or intentions based on trustor's knowledge, cognition, calculation, or emotion (Nooteboom, 2002). I shall focus on intentional trust for now and discuss competence trust in the next paragraph. Intentional trust is commonly defined as "a type of expectation that alleviates the fear that one's exchange partner will act opportunistically" (Bradach & Eccles, 1989). Firms engaged in repeated interactions may infer partner's intentions from their behaviours and outcomes in previous alliances. This knowledge-based intentional trust may arise at both the organization level and the individual level, which draws on the information collected from previous interactions (Gulati, 1995a; Nooteboom, 2002). Emotion-based and cognition-based trust may also arise at the individual level across firms, as organizational members develop shared norms, perceptions, interpretations, and evaluations over repeated interactions (Zaheer, McEvily, Perrone, 1998). The inter-personal trust and inter-organizational trust will reinforce each other, which relieve

the concerns of opportunistic behaviours. In particular, if firms believe their partners have good intentions in collaborative innovation, they would be less concerned about being taken advantage of, should they give away the control rights for incentive purposes.

In addition to intentional trust, firms may also develop competence trust as part of the learning process from previous alliances. Competence trust at the organizational level refers to firm's confidence in partner's fulfilment of certain task, based on their perception of partner's technological, commercial, organizational, and managerial competences (Nooteboom, 2002). The learning process in repeated collaboration involves (1) learning about their partners, (2) learning from their partners, (3) learning to structure better alliances, including writing partner-specific alliance contracts (Inkpen and Currall; 2004; Doz & Hamel, 1998; Kale, Dyer & Singh, 2002; Reuer & Arino, 2007; Ryall & Sampson, 2006). Competence trust is closely associated with the first type of learning, as firms develop knowledge about partner's various capabilities through previous alliances, and form better assessment on what they can deliver in future collaboration. Competence trust, together with intentional trust, relieves the concerns of partner's behavioural uncertainty, which helps firms to evaluate partner's potential contribution in collaborative innovation. Previous research on alliance formation shows that firms tend to favour those that they have partnered before, and weigh down against new partners to avoid relational risks (Gulai, 1995b; Hoetker; 2005)

Through prior collaboration, firms not only learn about their partners, but also learn to structure and manage alliances (Kale, Dyer & Singh, 2002). One of the important

steps in alliance structuring is contract development. Previous research suggests that firms learn from prior contracting experience to develop partner-specific or task-specific contracts to better motivate and coordinate with their partners (Reuer & Arino, 2007; Ryall & Sampson, 2006). As part of the learning process, firms will realize the importance of control rights to their partners and adjust the allocation of control rights in alliance contract to incentivise them.

In bio-pharmaceutical alliances, established pharmaceutical firms, on average, have stronger bargaining power than entrepreneurial biotech firms, and are likely to retain more control rights (Lerner & Merges, 1998; Lerner, Shane & Tsai, 2003). However, they also have several concerns in the allocation of control rights. First, pharmaceutical firms have concerns over biotech's self-interest seeking behaviours, i.e. whether the partner will take the control rights to develop competitive products or commercialize with other competitors. Second, pharmaceutical firms have concerns over partner's potential contribution in collaborative innovation under information asymmetry, i.e. whether they have the capability and the commitment to deliver the drug candidates. Third, pharmaceutical firms may focus on the private gains and neglect the importance of incentive design in collaborative innovation. The above concerns in the allocation of control rights can be relieved through prior interactions, as pharmaceutical firms build up trust with their biotech partners, learn about their competences, and develop partner-specific contract to incentivise them. Therefore, I hypothesize:

H1: Biotech firms that have prior collaboration with their partners are likely to receive more control rights in the collaborative innovation.

Future Collaboration and Biotech's Business Strategy

Inter-firm relationships are influenced not only by the prior collaboration experience, but also by the expectation of future collaboration, which forms the basis of relational contracts. Researchers have addressed the impact of relational contracts in long-term repeated collaboration from both economic and sociological perspectives, emphasizing on the importance of self-binding behaviours (Uzzi, 1997; Baker, Gibbons, & Murphy, 2002). From an economic perspective, a long-term relationship redirects firm's attention from private gains in single transaction to long-term benefits in repeated collaboration. As a result, firms are likely to commit into the collaboration, and refrain themselves from self-interest seeking behaviours (Plambeck & Taylor, 2006; Baker, Gibbons, & Murphy, 2002). From a sociological perspective, the benefits of an embedded tie featured by long-term repeated interactions include not only economic returns but also social support from the partners, such as information sharing and joint problem solving arrangements (Uzzi, 1996; 1997). To build up a long-term relationship, firms tend to withhold the bargaining power and treat their partner fairly in the collaboration (Heide & Miner, 1992). Previous research on the allocation of control rights suggests that firms with strong bargaining power on average retain more control rights for private benefits (Lerner & Merges 1998). However, in expectations of long-term repeated collaboration, firms are more likely to withhold their bargaining power to maintain a good relationship with their partners, which in turn shifts the allocation of control rights.

In the bio-pharmaceutical alliances, pharmaceutical firm's expectations of future collaboration are likely to be influenced by biotech's business strategy. Industrial report suggests that biotech firms usually follow two different strategies, namely the technology service strategy and the product development strategy (Business Insight, 2005). The technology service firms have advanced technologies, and are specialized in certain stage of drug development, such as drug discovery or delivery. They do not have proprietary pipelines, and their revenues rely heavily on providing technology services to other biotech and pharmaceutical firms. In contrast, the product development firms have broader range of capabilities, and are engaged in different stages of drug development, from discovery to clinical trials. They have their own pipelines in selected therapeutic areas, and may develop the drugs internally or jointly with other pharmaceutical firms. Although the product development firms may also provide services, their primary focus is on drug development. A major difference between the technology service firms and the product development firms is that the former has deep but narrow expertise, whereas the latter has much broader expertise in the value chain of drug development.

When pharmaceutical firms enter into R&D alliances with biotech firms, they typically start from one stage, i.e. drug discovery, and move forward along the value chain of drug development. (Please see Figure 1 for the process of drug development.) If the partners are service-based biotech firms, pharmaceutical firms are likely to terminate the collaboration once promising drug candidates are identified (or when the alliance matures), because their partners have no expertise in late-stage drug development. However, if the partners are product-based firms, pharmaceutical firms may continue the collaboration after the identification of promising drug candidates,

as they can rely on partner's expertise and background knowledge for joint development. With such a forward-looking view in mind, pharmaceutical firms can expect future collaboration with their partners following product development strategies. Plambeck & Taylor (2006) have pointed out that expectations of future interactions prevent firms from taking advantages of their partners at the initial stage, because 'doing so will damage their prospects for engaging their trading partners in the future', which in turn affects their long-term benefits in drug development. Such concerns are likely to take effect in the allocation of control rights, as pharmaceutical firms withhold their bargaining power to develop a long-term relationship with their partners following product-development strategies. Therefore, I hypothesize:

H2: Biotech firms following product development strategies are likely to receive more control rights in the collaborative innovation than those following technology service strategies.

Inter-firm Rivalry

In contrast to cooperative relationships which promote trust, learning, and self-binding behaviours, competitive relationships between the firms highlight the tensions and the risks of opportunistic behaviours in alliances. Park & Ungson (2001) argue that inter-firm rivalry is one of the key factors that lead to the instability and failures of alliances, as 'there exists a threat of each partner pursuing short-term and tangible gains by appropriating its partner and reneging on the contracts'. Hamel (1991) and Khanna, Gulati & Nohria (1998) also expressed the concerns that competition between the allying parties may accelerate the learning race in alliances. The learning

race takes place as firms tap into partner's knowledge base and apply the knowledge to their own projects for private benefits. In competitive alliances where firms have competing products or technologies, they have strong incentives to absorb partner's technologies and know-how and apply to their own technologies or products. If one party learns faster than the other, it may renege on the contract and terminate the collaboration in pursuit of market domination (Hamel, 1991; Khanna, Gulati & Nohria, 1998). Concerns of such opportunistic behaviours dissolve trust between the allying parties, which request safeguarding mechanisms in alliance governance (Park & Ungson, 2001; Das & Teng, 2000).

In the allocation of control rights, firms are concerned whether their partners would take advantages of them should they give away the control rights. Would the partner shelf the joint products and use the underlying technology to develop competing products? Or would they take the control rights to collaborate with external competitors? The concerns are especially strong when there is internal competition between the allying parties, as firms have strong incentives to exploit the control rights to strengthen their own products or technologies at the cost of their partners (Khanna, Gulati & Nohria, 1998; Oxley & Sampson, 2004). To protect their value appropriation and to avoid partner's exploitation, firms will try to internalize the control rights in alliance negotiation. In bio-pharmaceutical alliances, the inter-firm rivalry highlights the risks of self-interest seeking behaviours and the concerns of value appropriation, which promotes the use of bargaining power in the allocation of control rights. As biotech firms on average have less bargaining power, they may receive fewer control rights in competitive alliances. Therefore, I hypothesize:

H3: Biotech firms collaborating with pharmaceutical firms that have competing products or technologies are likely to receive fewer control rights in the collaborative innovation.

Task Uncertainty and the Relational Effect

In Williamson's early work (1975), he pointed out that uncertainty makes it difficult to predict a full range of contingencies, which leads to incomplete contracts and creates problems in enforcement. Furthermore, task uncertainty adds exogenous disturbances to task implementation, which makes it difficult to verify the causal link between task outcomes and individual/organizational behaviours. It is argued that the presence of task uncertainty itself does not necessarily lead to opportunistic behaviours; however, it provides room for opportunistic behaviours, as firms are unable to foresee, prevent, monitor or punish such behaviours under bounded rationality and cognitive limitations (Williamson, 1975; 1985). Whether or not firms will take the opportunity to behave opportunistically against their partners is called behavioural uncertainty, which arises from information asymmetry between the firms (Williamson, 1985). Behavioural uncertainty is a major threat to inter-firm collaboration, as firms may pursue their own interests at the cost of partner's benefits. The risks of behavioural uncertainty are highlighted under task uncertainty, as it is difficult to prevent and verify opportunistic and self-interest seeking behaviours in such cases.

Previous research suggests that firms are eager to remove the behavioural uncertainty when there is a high level of task uncertainty. Hoetker (2005) examined the sourcing

decisions of innovative components in the IT industry, and found that when task uncertainty is low, the decisions are made primarily on supplier's technological competences. However, as task uncertainty increases, firms tend to favour those with prior collaboration to remove behavioural uncertainties. At extreme levels of task uncertainty, firms have strong preference for internal suppliers to relieve the concerns of transactional hazards (Hoetker, 2005). Similar results have been found in partner selection and alliance performances (Li, Eden, Hitt, Ireland, 2008; Krishnan, Martin, & Noorderhaven, 2006). The results from previous studies suggest that behavioural uncertainty can be mitigated by relational mechanisms in repeated interactions (Nooteboom, Berger, Noorderhaven, 1997). Researchers argue that firms will develop trust with their partners through prior collaboration, and form better assessment on partner's intentions and competences, which relieves the concerns of opportunistic behaviours (Gulati, 1995a). In addition, expectations of future collaboration promote self-binding behaviours, which make partner's behaviours more predictable in congruence with collective goals (Nooteboom, 2002).

In the allocation of control rights, firms are concerned whether partners would take advantages of them under information asymmetry, and claim more than what they could deliver in collaborative innovation. The concerns are especially strong under task uncertainty, as it is difficult to verify such claims and prevent partner's opportunistic behaviours. The relational mechanisms, therefore, are more important in collaborative innovation with high levels of task uncertainty. In bio-pharmaceutical alliances, task uncertainty is closely associated with the stage of drug development. In early stages, firms are engaged in explorative activities, such as drug discovery and preclinical trials, which have high levels of task uncertainty. In late stages, firms are

involved in exploitative activities, such as clinical trials, which have lower levels of task uncertainty (Rothaermel & Deeds, 2004). In the allocation of control rights, the relational effect is likely to be stronger in early stages of drug development, as firms have greater concerns over partner's behavioural uncertainty under high levels of task uncertainty. Such concerns will be relieved, as firms develop mutual trust through prior collaboration, and take self-binding behaviours in expectations of future collaboration. Therefore, I hypothesize:

H4a: Biotech firms that have prior collaboration with their partners are more likely to receive more control rights in early stage of drug discovery than in late stage of drug development.

Pharmaceutical firm's expectations of long-term collaboration will be influenced by biotech's business strategy. Biotech firms that follow the product development strategies have broad capabilities from drug discovery to drug development. Biotech firms that follow the technology service strategies have deep but narrow expertise, which focuses mainly on drug discovery. Pharmaceutical firms entering into alliances at early stages of drug discovery are more likely to foresee long-term collaboration with product development biotech firms, as it is a long way to go from drug discovery to drug development, for which they would need partner's expertise and background knowledge. Therefore, I hypothesize:

H4b: Biotech firms following product development strategies are more likely to receive more control rights in early stage of drug discovery than in late stage of drug development.

Insert Figure 2 about here

Data & Methods

Sample & data

The sample is selected from Pharmaventures' database of bio-pharmaceutical alliances. Pharmaventure's database has similar structure as ReCap's database used in previous studies (i.e. Lerner & Merges, 1998; Lerner, etal, 2003; Higgins, 2007) with the advantage of world-wide coverage and unlimited access to raw contracts between the bio-pharmaceutical firms. The database contains all transactions in the bio-pharmaceutical industry from 1996 upwards, which include alliances, mergers, and acquisitions¹. The database has over 25,000 records, 30% of which have some coverage on research and development, and over 600 R&D alliances have detailed contracts. From these deals, I randomly selected 200 alliances formed prior to April 2006, eliminating the deals following the criteria of previous studies:

- One of the parties is a university, medical center, non-profit organization, or government agency.
- One party has a controlling interest in the other party.
- The agreement serves only as an amendment for an earlier alliance.
- The alliance involves only marketing or manufacturing with no R&D component.
- More than two parties are involved

¹ A small number of alliances in Pharmaventures' database were started from 1995, but announced in 1996.

For the completeness and consistency of firm-level data, I also exclude deals where

- The funding firm (pharmaceutical) is not listed
- The research firm (biotech) is not listed in the US market

The final sample contains 200 alliances with 74 funding firms (mainly pharmaceutical firms) and 107 research firms (mainly biotech firms). 10 firms (5% of the total firms) have served as both a research firm and a funding firm in different alliances. A yearly distribution of the alliances is attached in Table 1.

Insert Table 1 about here

The contract-level data extracted from the database contains information on the starting date and the end date of the alliance, the technology and products covered, the starting stage of the collaborative technology or products, total value of the deal, upfront payments, royalties, milestones, and equity investment. I corroborated and supplemented the data with information from firm's annual filings (i.e. 10-K). I then coded the control rights of collaborative innovation into three major categories, respectively product commercial rights, IP rights, and other contingency rights. Detailed information is provided in the description of dependent variable. The firm-level data and market-level data are traced from various sources, such as COMPUSTAT, DATASTREAM, Thomson Deals, Capital IQ, D&B Hoover's and firm's annual filings (i.e. 10-K).

Dependent Variable

The total number of control rights allocated to biotech firms

Based on the previous studies (Lerner and Merges, 1998; Lerner, etal, 2003), I coded the control rights awarded to biopharmaceutical firms into three major categories: respectively product development rights, IP rights, and contingency rights. A detailed list is provided below:

Product development Rights

1. Compound selection
2. Clinical trial
3. Process development
4. Regulatory filing
5. Manufacturing
6. Marketing

IP Rights

7. Ownership of joint technology
8. Patent prosecution of joint technology
9. License to access partner's technology
10. Right to sublicense
11. Right to license after the alliance
12. Publication
13. Right to receive knowledge/technology transfer

Other contingency Rights

14. Right to expand the alliance
15. Right to extend the alliance
16. Right to terminate the alliance without cause

When counting the control rights awarded to the biotech firms, I consider exclusive ownership of the right or licence as 1, partial or shared ownership, conditional option rights, non-exclusive license as 0.5, no right or licence as 0. In the analysis, total

number of control rights is used as a main dependent variable and the number of product development rights is used for robustness check.

Independent Variables

Biotech's prior collaboration with their partner

To measure biotech's prior collaboration with their partner, I counted the number of prior interactions between the biotech and the pharmaceutical firms from 1993 up to the time when they enter into alliances. Such interactions include various forms of alliances, including collaborative R&D, technology licenses, development and marketing agreements. I exclude pure extensions of prior alliances, and count only alliances on different products or therapeutic fields between the firms. I also use a dummy measure of whether or not the biotech has interacted with their partner before as a robustness check.

Biotech's business strategy

In the annual filings (i.e. 10-K), firms will describe their business strategy, and disclose whether they focus on technology service strategy or product development strategy. Firms that adopt the technology service strategies typically have statements close to the following: "Using our proven technology platform and drug design expertise, we seek to become the premier independent partner for lead generation, qualification and optimization programs. We believe we can reduce the time and cost of the compound discovery process and improve the quality of the compounds that

advance to the clinic”. Firms that adopt the product strategy strategies typically have statements close to the following: “We are a biotechnology company engaged in the research and development of small molecule cancer therapeutics based on a novel biological approach to cancer, our Activated Checkpoint TherapySM (ACTSM) platform, and our expertise in small molecule chemistry and intelligent drug design.” During the period of our analysis, 6 biotech firms are found to have changed their business strategies from technology service firms to product development firms, making statements close to the following “In the past we sought to become the premier partner of pharmaceutical companies for lead generation, qualification and optimization programs. While we will continue to forge strategic alliances that encompass these elements, our primary goal will be to design and produce independently small molecules that become medicines.” For the analysis, product development strategy is coded as 1, and technology service strategy is coded as 0.

Inter-firm rivalry between the biotech firms & their partner

In the annual filings (i.e. 10-K), firms will disclose the names of competitors that provide similar products or products in the section of competition. For example, in Arqule’s 2007 annual report, it states that “in the area of small molecule anti-cancer therapeutics, we have identified a number of companies that have clinical development programs and focused research and development in small molecule approaches to cancer, including: Ariad Pharmaceuticals, Inc.; Array BioPharma Inc.; Cell Therapeutics, Inc.; Curis, Inc.; Exelixis, Inc.; Onyx Pharmaceuticals, Inc.; OSI Pharmaceuticals, Inc.; Oxigene, Inc.; Pharmacopeia; Telik, Inc.; Kosan Biosciences, Inc.; and Vion Pharmaceuticals, Inc.” If partner’s name is included in the competitor’s

list, I considered it as a rival to the biotech firm. The competition between the allying firms is further verified using data from Capital IQ and Hoovers' databases. If the partner is a competitor to the biotech, then it is coded as '1', otherwise '0'.

Contingency Variable:

Task uncertainty (stage of the drug development)

Task uncertainty in bio-pharmaceutical alliances depends on the stage of drug development. A complete process of drug development includes target identification, lead identification, lead optimization, preclinical studies, IND, clinical trial phase I, phase II, phase III, NDA, Marketing/Phase IV (Lerner, Shane, & Tsai, 2003). Previous studies typically take the beginning of clinical trial as a breaking point for exploration and exploitation, which features a substantial reduction in task uncertainty (Rothermel & Deeds, 2004; Higgins, 2007). For the analysis, alliances started before clinical trials are coded as '1', indicating early-stage R&D with high task uncertainty. Alliances started from phase I onwards are coded as '0', indicating late-stage development with relatively lower task uncertainty.

Control variables

I control for the alternative explanations in the literature, such as firm's marginal contribution, bargaining power, and monetary incentives, following the measures used in previous studies (Lerner & Merges, 1998; Lerner, Shane, & Tsai, 2003; Higgins, 2007). For firm's marginal contribution, I controlled for *biotech & pharmaceutical*

firm's research intensity, measured using firm's R&D expenses divided by firm's sales revenue (one year prior to the alliance) from COMPUSTAT; *number of patents awarded to the biotech firms prior to the collaboration*; *biotech's general alliance experience*, measured using the number of alliances formed by the biotech prior to the collaboration.

For bargaining power, I controlled for the *financial health of biotech firms* based on return on equities (net income / share holder's equities), *the relative size between biotech firms and pharmaceutical firms* based on the ratio of their total assets from COMPUSTAT; *biotech's number of competitors* based on their annual reports, and information from Capital IQ and Hoover's database; *equity raised by the biotech industry* in the previous year, including IPOs, follow-ups, & convertible debts from Thomson Deals.

For monetary incentives, I controlled for *total value of the deals*, and the presence of *equity investment, upfront payment, milestones and royalties*.

Model

As the dependent variable *total number of control rights* is a count measure, I use the negative binomial regression for the analysis to account for over-dispersion in the data. As robustness checks, I repeat the analysis using ordered logit regression and fixed-firm effect OLS regression. The ordered logit model focuses on the ranking difference rather than the numerical difference in the allocation of control rights, treating two control rights as more favourable as one, but not necessarily twice as favourable. The

fixed-firm effect model controls for the time-invariant unobserved characteristics of pharmaceutical firms, which may influence the allocation of control rights in the collaborative innovation. However, given the limited observations within each panel (an average of 2.7 observations per panel), a high degree of freedom is lost in the regression. Adjustment is also made for heteroscedasticity and non-independence of intra-firm observations.

Results

Summary statistics and correlation matrix are presented in Table 2 & Table 3. For research firms, the average number of alliances in the sample is 2.84, with 12 firms (11%) having more than 3 alliances. For funding firms, the average number of alliances in the sample is 5.25, with 17 firms (23%) having more than 3 alliances. Among the 200 alliances, 69% (138 alliances) started from early-stage collaborative research, and 31% (62 alliances) were focused on late-stage joint development.

Insert Table 2 & Table 3 about here

The statistics also shows that the biotech firms on average hold minority control in collaborative innovation, with 4 control rights out of a total 16. The average deal size is about 115 million, with the largest deal reaching over 1 billion, which suggests the importance of collaborative innovation in the bio-pharmaceutical industry. The average return on equities for biotech firms is negative, suggesting that most of the biotech firms are under strict financial constraints.

In terms of the correlation, the total control rights and a break down of product development rights and IP rights awarded to the biotech firms are positively correlated, which suggest that there is no crowd-out effect between product development rights and IP rights. Public equity financing is highly correlated to biotech index; therefore, I use the former as a major indicator for public funding and the latter as a robustness check. The remaining variables do not have high correlation among themselves (mostly below 0.3), which are included in the regression.

Regression Analysis

Table 4 presents the results of negative binomial regression and fixed-firm effect OLS regression on biotech's total number of control rights. Model 1 & 2 include the main effects of biotech's partner-specific alliance experience, biotech's business strategy, and biotech's competition with their partner. Model 3 & 4 further include the interaction effects with task uncertainty (measured by the stage of drug development). There are a few variables that have lost their significance in the fixed-firm regression, both in the main effects and in the interaction effects. This is probably because the data has limited observations for each firm across years, and the model draws on within-panel variation, which takes away a high degree of freedom in the analysis.

Insert Table 4 about here

In hypotheses testing, hypothesis 1 predicts a positive relationship between biotech's total number of control rights and their partner-specific alliance experience. The results from all the four models show there is a significant and positive relationship

between biotech's total number of control rights and their partner-specific alliance experience, which well support the hypothesis. A robustness check using a dummy of whether or not biotech firm has prior collaboration with their partners finds similar results in the allocation of control rights.

Hypothesis 2 predicts a positive relationship between biotech's total number of control rights and their business strategy. The results show that biotech's business strategy is marginally significant in the main-effects models, but highly significant in the model where interaction effects are taken into account. The coefficients are significantly positive, which support the hypothesis.

Hypothesis 3 predicts a negative relationship between biotech's total number of control rights and the competitive relationship with their partners. The results from negative binomial regressions suggest there is a significant and negative relationship between the two. In the robustness check, the effect is not significant in the fixed-firm effect model. however, it is in the same direction as predicted. In general, the results are consistent with the hypothesis.

Hypotheses 4a and 4b predict positive relationships between biotech's total number of control rights and the interaction terms of repeated collaboration with the stage of drug development. The results from the interaction effect model suggest there are significantly positive relationships between the two. In the robustness check, the effect is not significant in fixed-firm effect model; however, it is in the same direction as predicted. In general, the results are consistent with the hypothesis.

In addition to the hypothesis testing, the results from the regressions show there is a high level of consistency between the present study and the previous studies on the allocation of control rights (Lerner & Merges, 1998; Lerner, et al, 2003). Variables catching the bargaining power (i.e. firm's relative assets, stage of the alliance, etc.), the marginal contribution (biotech's & partner's research intensities) and monetary incentives (total value of the deal, equity investment) are found to be significant as in previous studies.

Discussion

The present study demonstrates that inter-firm relationships have strong impact on the allocation of control rights, and the relational effect is stronger when task uncertainty is high. The relational effect is examined from both cooperative and competitive perspectives. Cooperative relationships, based on prior collaboration experience and future collaboration expectations, promote trust, learning and self-binding behaviours in collaboration, which relieve the concerns of opportunistic behaviours, and deepen the understanding of partner's potential contribution. Competitive relationships, based on inter-firm competition, highlight the tensions between the allying parties and the risks of partner's opportunistic behaviours, which make it difficult to assess partner's contribution, and prompts over-exploitation of firm's bargaining power in the allocation of control rights.

The present study extends prior research on the allocation of control rights in the following respects. First, it expands the framework from single transaction to repeated collaboration. Previous research aims to optimize the value creation and balance the

value appropriation in each single transaction, emphasizing on the distortion of incentives created by imbalanced bargaining power (Aghion & Tirole, 1994). In this paper, I do not attempt to solve the optimization problem for each transaction, but rather focus on how relational mechanisms solve the distortion in repeated collaboration. Second, previous studies tend to hold a strong view against bargaining power, assuming that firms will exploit their bargaining power under all conditions (Lerner & Merges, 1998; Lerner, et al, 2003). Although I agree bargaining power is an important factor in the allocation of control rights, I aim to shift the attention from a bargaining perspective to a relational perspective by explicitly considering situations where firms are less likely to use their bargaining power. Third, relational theories have been applied to various occasions (Gulati, 1995a; Hoetker, 2005; Dyer & Singh, 1998; Reuer & Arino, 2007; Ryall & Sampson, 2006). However, there are few studies that consider both the cooperative relationships and the competitive relationships from backward as well as forward looking perspectives. The current study provides a good setting to examine the different perspectives of relational theories, and the results seem to suggest that the same relational mechanisms, such as trust, learning, and self-binding behaviours work on different occasions.

The main implication from the present study is that the inter-firm relationship has an important role in the allocation of control rights, especially for firms with limited bargaining power. For small biotech firms, they may benefit more from long-term relationships with selected partners, as they are likely to receive more control rights in repeated collaboration. Those control rights will incentivise them to make more efforts in early-stage of drug development, which increase the chance of success. As a result, biotech firms engaged in long-term collaboration not only take a bigger slice of

the pie, but also benefit from a bigger size of the pie. From that point of view, small firms are better off to build up long-term relationships with focused partners rather than develop short-term relationships with multiple partners. This opens a new avenue for future research. Given that biotech firms have limited bargaining power, would it be better for them to increase their bargaining power by forming into alliances with different parties and reducing the dependence on any particular one? Or would it be better for them to invest in relational management and focus on the development of long-term relationships with selected partners? More generally, researchers are encouraged to explore the relationship between bargaining power and relational mechanisms, whether they are substitutes or complements, and under what condition one works better than the other.

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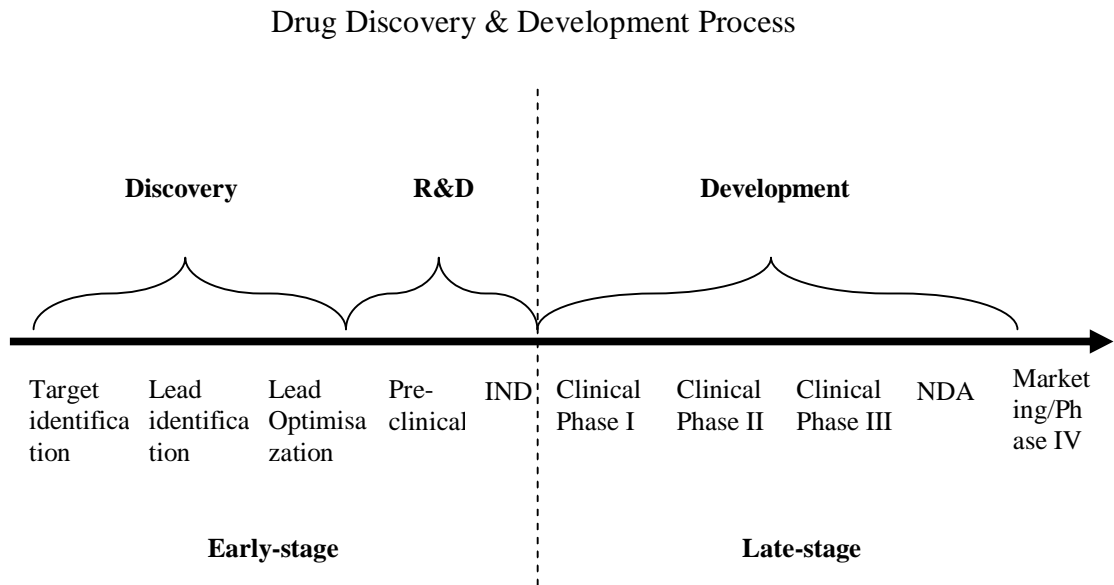


Figure 1: Drug Discovery & Development Process

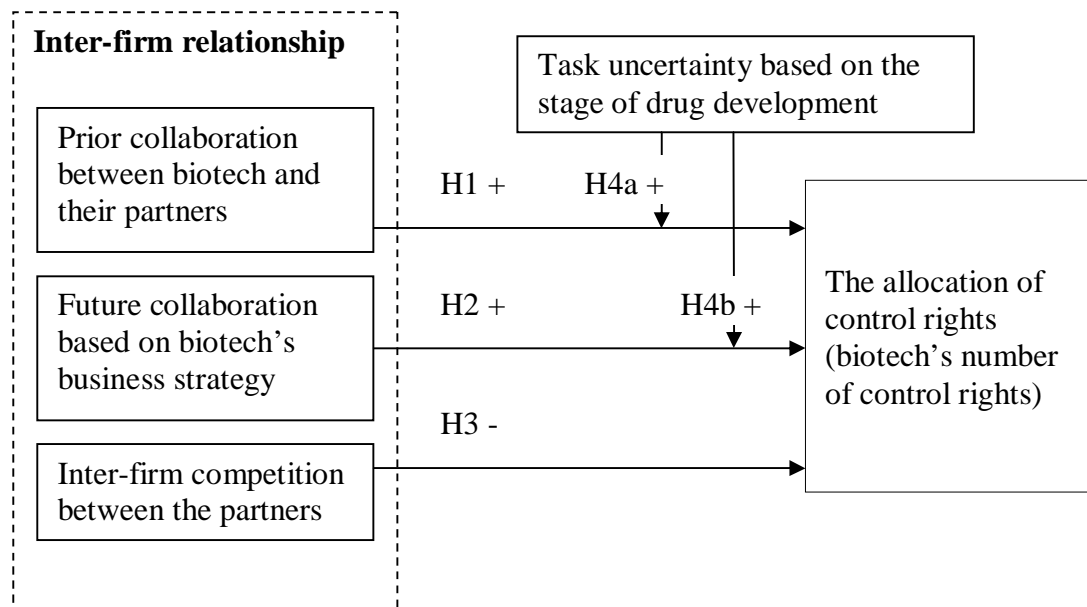


Figure 2: Model & Hypotheses

Table 1: Yearly Distribution of the Alliances

Year	Freq.	Percent	Cum.
1995	2	1.0%	1.0%
1996	13	6.5%	7.5%
1997	20	10.0%	17.5%
1998	15	7.5%	25.0%
1999	22	11.0%	36.0%
2000	31	15.5%	51.5%
2001	27	13.5%	65.0%
2002	23	11.5%	76.5%
2003	20	10.0%	86.5%
2004	12	6.0%	92.5%
2005	13	6.5%	99.0%
2006	2	1.0%	100.0%
Total	200	100.0%	

Table2: Summary Statistics

Variables	Mean	S.D.	Min	Max
Total control rights	4.37	2.24	0	10.5
Product commercial rights	1.87	1.58	0	6.0
IP rights	2.24	1.13	0	5.0
General alliance experience	18.41	23.03	0	142
Specific alliance experience	0.32	0.75	0	7
Business strategy: product (1) vs service (0)	0.77	0.43	0	1
Number of patents	21.26	36.90	0	263
Return on equities	-0.67	2.73	-16.4	20.7
RDintensity_biotech	13.557	42.993	0.037	389.188
Number of competitors	10.15	5.96	1	36
RDintensity_partner	0.752	4.392	0.019	59.798
Partner as competitor (1)	0.24	0.43	0	1
Relative size (bio/pharma)	-4.44	2.86	-9.8	7.0
Alliance stage: clinical (1) vs non-clinical (0)	0.31	0.46	0	1
Total value of the deal	115.60	182.12	0.7	1340.0
Upfront fee (dummy)	0.77	0.42	0	1
Equity invest (dummy)	0.43	0.50	0	1
Milestone (dummy)	0.80	0.41	0	1
Royalty (dummy)	0.76	0.43	0	1
Public equity financing	7.72	6.49	0.5	20.8
Biotech index	661.15	285.94	161.4	1084.5

Table 2-1 Correlation Table

Variables	1	2	3	4	5	6	7	8	9	10
1. Total control rights	1.00									
2. Product development rights	0.83*	1.00								
3. IP rights	0.68*	0.21*	1.00							
4. Biotech's general alliance experience	0.11	0.08	0.12	1.00						
5. Biotech's specific alliance experience	0.18*	0.07	0.24*	0.07	1.00					
6. Biotech's business strategy: product(1) vs service(0)	0.20*	0.30*	0.01	0.00	0.03	1.00				
7. Biotech's number of patents	0.13	0.02	0.23*	0.22*	0.33*	0.24*	1.00			
8. Relative total assets (biotech/pharma)	0.14*	0.14*	0.09	0.36*	-0.06	0.03	0.12	1.00		
9. Biotech's ROE	0.12	0.07	0.15*	0.09	0.02	-0.05	0.11	0.18*	1.00	
10. RDIntensity_biotech	0.12	0.17*	0.02	-0.09	0.02	0.15*	-0.03	-0.17*	-0.17*	1.00
11. RDIntensity_partner	-0.05	0.01	-0.09	-0.02	0.03	0.04	0.12	0.28*	0.02	-0.04
12. Biotech's number of competitors	0.05	0.07	0.00	0.23*	-0.12	0.06	0.02	0.23*	-0.09	-0.12
13. Partner as competitor (1)	-0.08	-0.05	-0.07	-0.07	-0.10	0.23*	-0.02	-0.07	-0.01	0.15
14. Total value of the deal	0.22*	0.17*	0.23*	0.22*	0.03	0.02	0.11	-0.07	0.07	0.09
15. Stage of alliance: clinical (1) vs non-clinical (0)	0.23*	0.44*	-0.10	-0.07	-0.06	0.35*	-0.06	-0.10	0.05	0.20*
16. Royalty (dummy)	-0.08	-0.11	-0.04	-0.02	-0.04	-0.04	-0.08	-0.13	0.05	-0.02
17. Milestone (dummy)	-0.05	-0.02	-0.09	-0.04	-0.11	0.04	-0.11	-0.20*	0.02	0.04
18. Equity invest (dummy)	0.17*	0.15*	0.10	-0.05	-0.04	0.12	-0.07	-0.11	0.06	0.07
19. Public equity financing	0.03	0.03	0.05	0.27*	0.02	0.07	0.18*	0.30*	-0.01	-0.08
20. Biotech index	0.04	0.09	-0.01	0.21*	-0.01	0.02	0.08	0.32*	0.07	-0.01

Table 2-2 Correlation Table-Continued

Variables	11	12	13	14	15	16	17	18	19	20
11. RDintensity_partner	1.00									
12. Biotech's number of competitors	-0.02	1.00								
13. Partner as competitor (1)	-0.05	0.23*	1.00							
14. Total value of the deal	-0.03	0.05	0.13	1.00						
15. Stage of alliance: clinical (1) vs non-clinical (0)	0.07	0.01	0.05	0.21*	1.00					
16. Royalty (dummy)	-0.14*	-0.06	0.02	0.05	-0.02	1.00				
17. Milestone (dummy)	-0.19*	-0.02	0.05	0.13	0.15*	0.60*	1.00			
18. Equity invest (dummy)	-0.10	-0.05	0.06	0.20*	0.06	0.18*	0.16*	1.00		
19. Public equity financing	0.18*	0.15*	0.15*	0.12	-0.10	-0.21*	-0.22*	-0.09	1.00	
20. Biotech index	0.14*	0.17*	0.09	0.11	0.00	-0.17*	-0.12	-0.11	0.72*	1.00

* significant at 0.05 level or above

Table 4: Results of Regression Analysis (Biotech's total number of control rights)

Dependent variable	Biotech's total number of control rights			
	Model1 (NB)	Model2 (fixed effects)	Model3 (NB)	Model4 (fixed effects)
Biotech's partner specific alliance experience	0.101*** (0.010)	0.509** (0.027)	0.087** (0.044)	0.540** (0.023)
Biotech's business strategy	0.198* (0.058)	1.066* (0.069)	0.507*** (0.000)	1.444** (0.026)
Partner as a competitor	-0.231** (0.027)	-0.851 (0.179)	-0.212** (0.049)	-0.828 (0.207)
Stage of the alliance (early 1 vs late 0)	-0.208** (0.005)	-0.723* (0.07)	0.047 (0.495)	-1.066 (0.469)
Biotech's general alliance experience	0.000 (0.92)	0.007 (0.417)	0.001 (0.306)	0.010 (0.300)
Biotech's patents	-0.000 (0.841)	-0.002 (0.63)	-0.001 (0.362)	-0.003 (0.511)
Biotech's number of competitors	0.005 (0.39)	-0.026 (0.33)	0.007 (0.236)	-0.023 (0.456)
Relative size (total assets of biotech/ pharma)	0.033** (0.023)	0.344* (0.067)	0.025 (0.118)	0.314 (0.117)
Biotech's ROE	0.012 (0.515)	-0.025 (0.783)	0.003 (0.848)	-0.031 (0.729)
Biotech's R&D intensity	0.001 (0.223)	0.007 (0.16)	0.003*** (0.000)	0.009** (0.049)
Partner's R&D intensity	-0.017*** (0.003)	-0.294 (0.306)	-0.014*** (0.000)	-5.851 (0.448)
equity finance market	0.008 (0.21)	0.023 (0.586)	0.007 (0.321)	0.016 (0.711)
Total value of the deal	0.000*** (0.005)	0.000 (0.401)	0.000*** (0.001)	0.001 (0.349)
royalty	-0.046 (0.608)	-0.034 (0.962)	-0.088 (0.266)	-0.217 (0.777)
milestone	-0.023 (0.838)	-0.176 (0.828)	0.054 (0.621)	0.045 (0.961)
equity	0.121** (0.046)	0.641* (0.07)	0.148*** (0.008)	0.634* (0.091)
Early-stage* Biotech's specific alliance experience			0.175* (0.067)	0.287 (0.619)
Early-stage* Biotech's business strategy			1.268*** (0.000)	2.268 (0.226)
Early-stage* Biotech's partner as a competitor			0.092 (0.580)	0.863 (0.369)
Early-stage* Biotech's general alliance experience			0.004* (0.073)	0.016 (0.232)
Early-stage* Biotech's patent			0.001 (0.315)	0.005 (0.622)
Early-stage* Biotech's number of competitors			0.004 (0.631)	-0.000 (0.998)
Early-stage* Biotech's R&D intensity			0.004*** (0.001)	0.004 (0.471)
Early-stage* Partner's R&D intensity			0.066 (0.354)	7.485 (0.468)
Observations	177	177	177	177

(Pseudo) likelihood/R-squared	-367.35	∴	13.4	-361.05	∴	0.0076
Robust p values in parentheses	* significant at 10%; ** significant at 5%; *** significant at 1%					