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**INTRA-ALLIANCE PERFORMANCE,
CONTROL RIGHTS, AND TODAY'S SPLIT
OF TOMORROW'S VALUE**

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INTRA-ALLIANCE PERFORMANCE, CONTROL RIGHTS, AND TODAY'S SPLIT OF TOMORROW'S VALUE

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Abstract

Although the differential benefits reaped by individual partners are a major determinant of the performance impact of strategic alliances, previous analysis has faced methodological challenges. In response we propose a measure for relative value appropriation and an explicit theoretical framework for predicting its variation in terms of relative bargaining position. With a sample of 180 biotechnology R&D alliances, we are thus able to explain variation in value appropriation across partner types as well as individual partners of each type.

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INTRA-ALLIANCE PERFORMANCE, CONTROL RIGHTS, AND TODAY'S SPLIT OF TOMORROW'S VALUE

How is the value created by an alliance split between its members? When an alliance is successful, do the partners share equally in the value created, and if not why not? What determines how a “pie” is split between the members of the coalition that creates it?

The impact of strategic alliances on the performance of individual alliance partners is an important yet under-explored area in strategic management research. In general, “empirical work investigating the performance of individual alliances is scarce, largely because of methodological barriers” (Hoang and Rothaermel, 2005: 332). Yet this problem is even more pronounced at the level of individual alliance partners.

Alliance partners are not only interested in overall alliance performance, but also in how much they individually gain from the partnership. Thus it is not enough to consider alliance success independently of how much each partner benefits from such success, as this latter criterion is arguably more important to the individual firm.

However, analyzing the performance of individual alliance partners poses significant methodological challenges. For instance, “since many other activities besides alliances can also influence the performance of firms, it can be difficult to empirically link the alliance activity of firms with their performance” (Gulati, 1998: 309).

In response, we propose a new theoretical approach and a new measure of value appropriation, which we use to predict and test the determinants of the amount of value created by an alliance that each partner appropriates.

Our theoretical approach derives from work by Adegbesan (2005) who uses the recent “bargaining perspective on resource advantage” (Lippman and Rumelt, 2003) to extend strategic factor market theory (Barney, 1986; Makadok and Barney, 2001) to account for situations where acquiring firms display varying degrees of complementarity to target resources. He shows that the amount of value firms stand to capture in such markets depends on the relative supply/demand of buyer and seller groups, the relative degree of complementarity between individual buyers and target resources, and the bargaining ability of individual buyers relative to individual resource suppliers. Thus value appropriation is jointly determined by inter-group, intra-group, and intra-pair bargaining over surplus.

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We apply this theory to alliance performance in the context of biotechnology R&D alliances. We conceptualize biotechnology R&D alliances as taking place in strategic factor markets where pharmaceutical firms source for specialized knowledge and research skills, while biotechnology firms source for funding along with product development, approval process and marketing capabilities. As such, there is simultaneous demand and supply for *both* pharmaceutical and biotechnology firms. The resulting competition impacts the “splitting of the pie” in the alliances that eventually form. Unlike previous studies, we concurrently consider firm-level, alliance-level, and group-level determinants of value appropriation. Thus one of the questions we seek to answer is “which firms, of which type are able to get the best deals, and why?”

We proxy the division of created value with the share of a key subset of alliance control rights won by each partner. Previous literature has tended to look at control rights as a homogenous set responding only to concerns of output maximization and opportunistic behavior. We argue, however, that control rights are not homogenous, and fulfill different functions such as the splitting of an uncertain future pie, distribution of tasks and responsibilities, planning for foreseeable contingencies, efficient alignment of ex post behavior, signalling of congruence, etc. Consequently, lumping all of them together leads to ambiguous results.

In this paper, we focus on the percentage of a subset of ten “pie-splitting” control rights won by each partner. “Pie-splitting” (PS) control rights confer ownership and control over activities and decisions directly related to the allocation of portions of the overall value to be created by an alliance. As such we suggest that bargaining over pie-splitting control rights helps alliance partners to work around the uncertainty involved in splitting future value in the present.

We test our predictions by analyzing a sample of 180 biotechnology R&D alliances entered into by 38 pharmaceutical and 108 biotechnology firms between 1993 and 2000. Among other results, we find that PS control rights act as substitutes for royalty payments and they appear to track performance more closely than a simple count of undifferentiated control rights. We also find that pharmaceutical firms *as a group* appropriate more value when the average external R&D spending by pharmaceutical firms is lower, and alternative funding is less available for biotechnology firms. On the other hand, R&D firms do better *as a group* when the availability of projects in late-stage research is lower. In addition, individual R&D firms outperform *their peers* when their weighted patent count or their previous alliance experience is greater; while they may perform better *relative to their pharmaceutical partner* when its new product pipeline is weaker. Similarly, pharmaceutical firms do better *relative to their peers* when their experience with late stage alliances is greater; while they may perform better *relative to their biotech partner* when its need for external financing is higher.

The rest of the paper is organized as follows: In the next section, we start off with a review of the relevant literature, followed by an outline of our theoretical approach. We then use our theory to generate a series of hypotheses, the tests of which are detailed in the following section. Following these, we discuss the implications, extensions, and limitations of our findings, before concluding.

Control Rights, Strategic Factor Markets, and Value Appropriation in R&D Alliances

Previous research into the performance impact of strategic alliances on the firms entering into them has been hampered by the difficulties involved in disentangling alliance performance effects

from those due to other firm activities. In addition, the confidentiality of the fine-grained data required has made it difficult to measure and predict the relative performance of alliance partners. For these reasons scholars have employed “a variety of direct and indirect means to test this relationship” (Gulati, 1998: 309), and two major approaches can be highlighted (*ibid*).

On the one hand, event study analyses of stock market reactions to alliance announcements (e.g. Anand and Khanna, 1997; Balakrishnan and Koza, 1993; Koh and Venkatraman, 1991) have been used to proxy the likely future impact of alliances on performance. On the other hand, researchers have considered the impact of the *extent* of alliance activity on firm performance, generally narrowing the domain of performance explained to measures of innovative output such as patents or new products (e.g. Ahuja, 2000; Hagedoorn and Schakenraad, 1994; Mowery, Oxley, and Silverman, 1996; Rothaermel and Deeds, 2004).

While these approaches have undoubtedly advanced knowledge, they have nonetheless provided mixed evidence (Gulati, 1998), and their performance measures suffer from at least two problems: Firstly, in many cases (e.g. stock market reactions), the performance measures are not causally proximal to activities involved in the alliance process itself. Secondly, performance measures are often one-sided and unable to distinguish relative performance effects for the distinct alliance partners, as opposed to performance effects for one focal alliance partner.

Alliance Contractual Design

In a parallel development, research on alliance design is focusing increasingly on the contractual provisions firms use to structure their relationships (e.g. Luo, 2002; Mayer and Argyres, 2004; Poppo and Zenger, 2002; Reuer, Ariño, and Mellewigt, 2005; Ryall and Sampson, 2003). Previous work on alliance design had mostly focused on the choice of governance form, addressing the question of when equity or non-equity arrangements would provide the optimal alliance structure (e.g. Gulati, 1995; Hennart, 1988; Oxley, 1997; Pisano, 1989). In this respect, it was assumed that equity alliances conferred greater control than non-equity alliances because of their shared ownership and joint boards (Ariño and Reuer, 2005).

However recent empirical studies show that contracts of non-equity alliances can and do incorporate numerous provisions to help control partner behavior (Mayer and Argyres, 2004; Ryall and Sampson, 2003). As such, “parties to an alliance have considerable latitude in allocating duties, risks, procedures, and so forth, through individual contractual provisions that specify exchanges in more precise terms” (Reuer and Ariño, 2003: 1). In addition, there is substantial contractual heterogeneity within particular governance forms such that many key clauses are as likely to appear in equity as in non-equity alliances (Ariño and Reuer, 2005; Reuer et al., 2005), thus making a sole focus on the equity/non-equity distinction problematic (Ryall and Sampson, 2003: 5-6).

These studies suggest that the analysis of contractual provisions can provide a bridge between research on alliance design and research on alliance performance, because contracts also specify the distribution of gains between alliance partners (Elfenbein and Lerner, 2003). Already, a number of authors (e.g. Ariño, Reuer, Mayer, and Jané, 2005; Poppo and Zenger, 2002; Reuer and Ariño, 2005; Ryall and Sampson, 2003) have examined determinants of contractual complexity [since contractual provisions can be costly and time-consuming to negotiate, monitor, and enforce (Argyres and Mayer, 2004; Madhok and Tallman, 1998; Zaheer, McEvily, and Perrone, 1998), complexity is related to contracting costs and alliance

performance]. However, an important area yet to be explored is how contractual provisions reflect the distribution of returns on collaborative activity. This is important because the allocation of rights of control over returns on collaborative activity has a direct impact on the performance of each alliance partner.

Bargaining over Control Rights in Biotechnology R&D Alliances

“The biotechnology industry has been identified as the industry with the highest alliance frequency among several industries characterized by high alliance activity” (Rothaermel and Deeds, 2004: 208). This industry has seen thousands of R&D alliances between pharmaceutical and biotechnology firms since the discovery of recombinant DNA technology in 1973. Biotechnology projects are highly complex and unpredictable, making it very difficult to specify the features of the product to be developed *ex ante* (Henderson and Cockburn, 1994; Pisano, 1990). In addition, even though the entire process may last more than 15 years and cost over \$500 million for a single drug, the probability that any given research compound will eventually develop into an approved drug is only 0.01% (Rothaermel and Deeds, 2004).

Given the associated uncertainties, partner firms cannot directly bargain over the distribution of future income streams, but rather over *the control of activities and decisions related to those possible streams*. Consequently, the amount of value individual partners stand to appropriate in the future depends on the distribution of a key subset of the alliance’s (“pie-splitting”) control rights. For this reason, “the allocation of control rights is a central issue in the negotiation of alliances” (Lerner and Merges, 1998: 127).

“Pie-splitting” control rights. Early theoretical examination of the allocation of control rights in alliances built on the property rights approach to the theory of the firm (Grossman and Hart, 1986; Hart and Moore, 1990). In this framework, the allocation of control rights is driven by concerns of efficient *ex ante* investment levels, such that control is allocated to the party that is most important for the success of the project (Grossman and Hart, 1986). In an important paper, Aghion and Tirole’s (1994) model of R&D sourcing extended this idea, adding bargaining power to concerns of underinvestment, as drivers of the allocation of control.

However, empirical studies have provided mixed support for these assertions. For instance, although Lerner and Merges’ (1998) study of 200 biotechnology alliances found that the allocation of control rights was strongly influenced by the financial strength of the R&D firms, they found no impact of efficiency/underinvestment concerns. Similarly, Higgins’ (2005) study of 165 alliances found that control rights allocation was influenced mainly by partner bargaining power. Nevertheless Elfenbein and Lerner’s (2003) study of Internet portal alliances found that while allocation of one subset of rights was responsive to efficiency predictions, the allocation of other control rights was responsive to the relative bargaining positions of the partners. Additionally, Lerner, Shane, and Tsai (2003) found that when focusing on a subset of five control rights, alliance outcomes were consistent with Aghion and Tirole’s (1994) predictions, but when they “use the measure of 25 control rights however, the association between strength of financial markets and control assigned to the biotechnology firm is no longer significant at conventional confidence levels” (Lerner et al., 2003: 432).

We hold that these results demonstrate the importance of distinguishing between different subsets of control rights with distinct functions. Research on alliance contractual design has shown that the allocation of control and decision rights responds to varied concerns such as the splitting of an uncertain future surplus, the distribution of tasks and responsibilities, planning

for foreseeable contingencies, efficient alignment of *ex post* behavior, signaling of congruence, and efficient *ex ante* investment, among others (e.g. Ariño and Reuer, 2005; Dessein, 2005; Oxley, 1997; Ryall and Sampson, 2003). Consequently empirical tests of theory can be confounded by the distinct allocation mechanisms underlying different subsets of control rights. For this reason, in predicting *value appropriation*, we extend research on control rights by focusing on a subset we call “pie-splitting” (PS) control rights.

PS control rights confer ownership and control over activities and decisions that directly affect the allocation of portions of the overall value to be created by an alliance. As such they help alliance partners to work around the uncertainty involved in splitting future value in the present. Bargaining over PS control rights is similar to bargaining over options on future income because they confer the ability to make decisions affecting the creation and distribution of an income stream whose magnitude and even existence are uncertain *ex ante*. For this reason the allocation of PS control rights dictates how much an individual firm will profit from the relationship (Higgins, 2005).

As we will discuss later, we identified PS control rights after an extensive literature review, an in-depth analysis of 56 different contractual clauses for each alliance in our sample, a detailed analysis of the biotechnology control rights used by Lerner and Merges (1998), Higgins (2005), and Lerner et al. (2003), and contributions from practitioners.

Early- and late-stage markets. We conceptualize biotechnology alliances as taking place in double-sided strategic factor markets (Adegbesan, 2005; Barney, 1986; Lippman and Rumelt, 2003). Biotechnology firms contribute specialized knowledge and research skills, while pharmaceutical firms contribute funding along with product development, approval process and marketing capabilities. In setting out the terms of their alliance, the partners bargain over the sharing of PS control rights related to their collaborative relationship.

Our conceptualization builds on an important insight from Higgins (2005) who shows that the “relative bargaining position of *both* firms impacts the underlying allocation of control rights” (ibid: 3). Previous literature (flowing from the property rights stream) had overlooked the fact that in addition to R&D firms jostling for funding, pharmaceutical firms also compete among themselves to ally with more valuable biotechnology firms (Higgins, 2005; Higgins and Rodriguez, 2005). Therefore, since the dynamics of relative bargaining position vary with the stage of development of the lead product candidate when the alliance is signed (Higgins, 2005; Lerner and Merges, 1998), we go a step further by decomposing our double-sided market into two sub-markets corresponding to early- and late-stage alliances.

In early-stage alliances, cash-strapped R&D firms find it difficult to raise equity or debt due to the informational asymmetries surrounding their specialized work (Lerner and Merges, 1998). They thus turn to pharmaceutical firms which are better able¹ than non-specialized investors to evaluate their prospects (Lerner et al., 2003). To a large extent therefore, pharmaceutical firms can pick the firms they choose to fund, as their research dollars are scarcer than the R&D firms seeking early-stage research funding (Powell and Brantley, 1992; Stern and Dukerich, 2006). Nevertheless, since pharmaceutical firms enter into R&D alliances in the hope of eventually developing new drugs, biotechnology firms with superior capabilities or reputations will retain bargaining power relative to other biotechnology firms, as there will be residual competition among pharmaceutical firms to ally with more valuable R&D firms (Stern and Dukerich, 2006).

¹ Or at least, less unable.

The roles are significantly reversed in markets for late-stage alliances. Productivity in the pharmaceutical industry has declined in the last decade with more drugs losing exclusivity protection than the number of new drugs approved by the regulatory authorities (Higgins and Rodriguez, 2005). The industry had approximately 1,146 years of aggregate exclusivity protection in 1998, but this had fallen to just over 800 years by 2001, with a fairly rapid rate of decline (Higgins, 2005). Thus since the farther advanced a research project is the higher its likelihood of success, late-stage research projects are very attractive to pharmaceutical firms (Higgins, 2005; Rothaermel, 2001).

At the same time however, biotechnology firms with late-stage research projects have better access to external funding, since success in earlier stages alleviates information problems (Dessein, 2005; Lerner et al., 2003) and enhances their credibility with investors. Thus pharmaceutical firms have to compete for the fewer available biotechnology firms with late-stage research projects (Higgins, 2005). Nevertheless, since many biotechnology firms lack experience of taking new drug projects from clinical trials and regulatory approval through manufacturing to marketing (Rothaermel, 2001), pharmaceutical firms with superior research, clinical testing and marketing capabilities will retain bargaining power relative to other pharmaceutical firms (Helfat, 1997; Henderson and Cockburn, 1994).

Bargaining over value in strategic factor markets. We analyze the determinants of value appropriation in these two markets drawing on work by Adegbesan (2005) that extends strategic factor market theory (Barney, 1986; Makadok and Barney, 2001) to account for situations where buyers display varying degrees of complementarity to target resources (Lippman and Rumelt, 2003). The prevalent view in research on strategic factor markets has been that firms cannot appropriate gains from the deployment of valuable resources unless they have superior expectations about their future value, or they benefit from luck (Ahuja, Coff, and Lee, 2005; Barney, 1986; Denrell, Fang, and Winter, 2003; Makadok and Barney, 2001). Nevertheless, despite its broad acceptance, this conclusion is true only when there are no complementarities between resources (Conner, 1991; Lippman and Rumelt, 2003; Barney, 1988; Adegbesan, 2005).

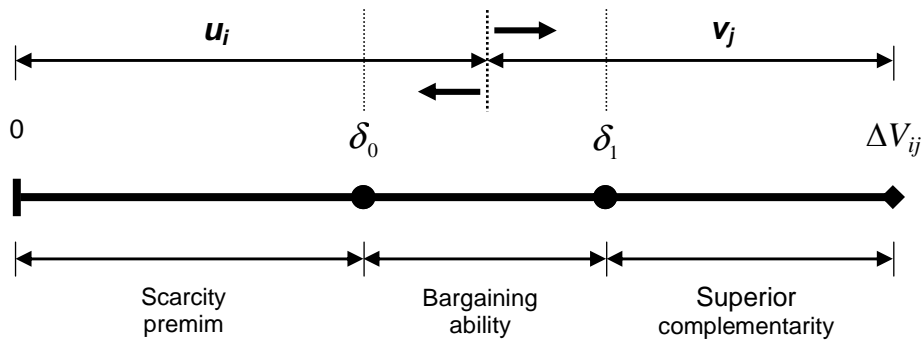
When there are no complementarities between resources, if the value of a resource R_1 on its own is $v(R_1)$ and the value of another resource R_2 is $v(R_2)$, then in combination their value is at most $v(R_1 \cup R_2) = v(R_1) + v(R_2)$. Thus $v(R_1)$ would be the marginal productivity of R_1 in the combination and Barney's (1986) logic holds: unless the supplier of R_1 doesn't know what it is worth (asymmetric information), the owner of R_2 cannot pay less than $v(R_1)$ for the services of R_1 . As such, a resource buyer cannot get more than she pays for.

However, when there is some degree of co-specialization (complementarity) between the resources, their combination is "superadditive" and $v(R_1 \cup R_2) = v(R_1) + v(R_2) + \Delta V$ where $\Delta V > 0$ (Adegbesan, 2005; Thomke and Kuemmerle, 2002). The magnitude of the surplus created (ΔV) is proportional to the degree of complementarity between the resources. It does not "belong" to either resource but results from their combination, and the way it is split between them is therefore indeterminate ex ante. Thus if the owner of R_2 is able to appropriate a positive share of the surplus ΔV , she can realize gains to trade even if she had to pay $v(R_1)$ for the services of R_1 .

Adegbesan (2005) builds on the "bargaining perspective on resource advantage" (Lippman and Rumelt, 2003) to show that the portion of surplus captured by each partner depends on the joint effects of the *relative supply/demand* of seller and buyer groups; the *relative degree of complementarity* between individual buyers and target resources; and the *bargaining ability* of individual buyers relative to individual resource suppliers.

Figure 1

Competition and Bargaining in Value Appropriation



This is illustrated² in Figure 1 in the context of an alliance where two partners, i and j , split a surplus $\Delta V_{ij} = u_i + v_j$. Adegbesan (2005) formally shows that some of the surplus will be *guaranteed to the scarcer partner* in proportion to the value it could create with the most valuable *unmatched* player (δ_0); some will be *guaranteed to the bidding partner* in proportion to its superior complementarity relative to its least valuable *matched* peer ($\Delta V_{ij} - \delta_1$); and a final portion is split according to the relative bargaining ability of the alliance partners *within* a pair ($\delta_1 - \delta_0$). Thus all else being equal, the greater a partner's relative scarcity, superior complementarity, or relative bargaining ability, the greater the value it stands to appropriate from the alliance.

Hypotheses

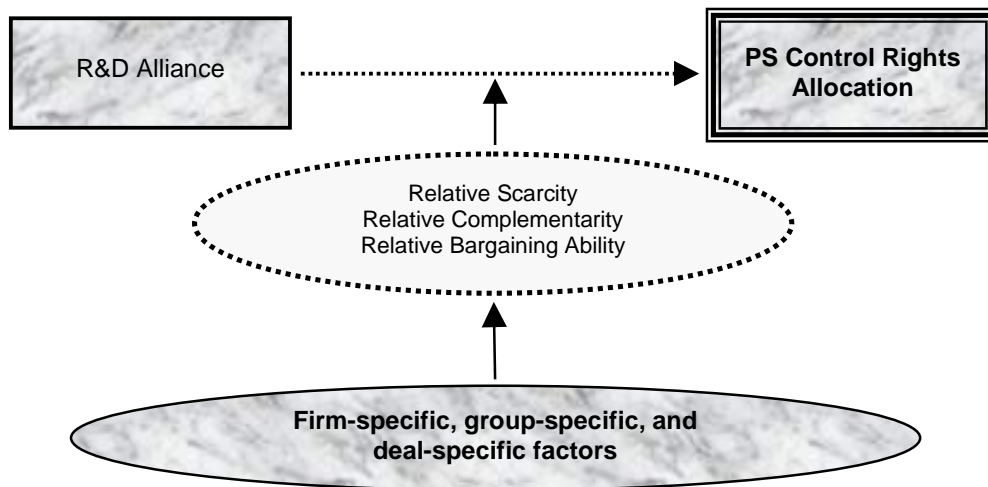
We use this bargaining model to link the extant literature to the division of PS control rights in biotechnology R&D alliances. When biotechnology firms enter into R&D alliances with pharmaceutical firms, their bargaining positions depend on the values taken by the variables ΔV_{ij} , δ_1 , and δ_0 shown above. ΔV_{ij} represents the future surplus that any given pair of firms $\{i, j\}$ bargains over, δ_1 represents the surplus that the least valuable pair bargains over, and δ_0 represents the surplus that could be created in an alliance with the most valuable unpaired firm (Adegbesan, 2005).

As illustrated in Figure 2, the division of PS control rights is determined by the relative bargaining positions of the alliance partners. In turn, however, their bargaining positions arise from the impact of a series of factors deriving from relative scarcity, relative complementarity, and bargaining ability. We thus use insights from previous work on R&D alliances to generate hypotheses on how these firm-specific, alliance-specific, and environmental factors affect variation in the parameters, and thus variation in the share of PS control rights each individual firm stands to win.

² Illustration from Adegbesan (2005).

Figure 2

Determinants of Division of PS Control Rights



Early-stage alliances: relative scarcity. As we discussed earlier, biotechnology firms with early-stage projects have limited access to non-specialized funding (Lerner et al., 2003). Pharmaceutical firms on the other hand have limited resources to spend on external R&D (Pisano, 1990). Thus the number of early-stage projects brought to the alliance market tends to outstrip the available financing, such that pharmaceutical firms can pick and choose which of the bidding projects to fund (Powell and Brantley, 1992). As R&D firms vary in quality (Dessein, 2005), those perceived to be more valuable will be preferentially funded, while some of the less valuable ones will not receive funding (Powell and Brantley, 1992; Stern and Dukerich, 2006). Each pharmaceutical firm is thus guaranteed to appropriate at least ∂_0 (see Figure 1), the value that could be created with the *best unfunded* R&D firm (Adegbesan, 2005).

Consequently, the lower the biotechnology funding received from pharmaceutical firms in a given period, the fewer the R&D firms that receive funding and thus the more valuable the best unfunded R&D firm is (in other words, the greater ∂_0 is). As we saw earlier, the greater ∂_0 is, the greater the share of PS control rights guaranteed to the scarcer partner (the pharmaceutical firm in this case). So we hypothesize:

*Hypothesis 1. For early-stage alliances, the lower the availability of pharmaceutical funding in a period, the higher the percentage of PS control rights won by each pharmaceutical firm.*³

Early-stage alliances: superior complementarity. In spite of the uncertainty surrounding R&D projects, pharmaceutical firms seek to enter into alliances with more promise of leading to successful new drugs (Hill and Rothaermel, 2003). The variance in quality of R&D firms thus ensures there is still some competition between pharmaceutical firms to ally with biotechnology firms perceived to be more valuable (Stern and Dukerich, 2006). Consequently, as Adegbesan (2005) shows, more valuable biotechnology firms will be guaranteed a level of appropriation proportional to their superior complementarity.

³ Since we consider the *share* (percentage) of PS control rights won by a partner, a pharmaceutical firm's gain (of PS control rights) is its biotechnology partner's loss and vice-versa.

A biotechnology firm's superior complementarity ($\Delta V_{ij} - \partial_1$) measures *how much more* value it is likely to create with pharmaceutical dollars, than the least valuable of the R&D firms that actually get funded. The greater the value of an R&D firm relative to the least valuable funded R&D firm, the more PS control rights it retains (ibid).

One important way pharmaceutical firms appraise the value of biotechnology firms is by evaluating their patent portfolios. An R&D firm's patent portfolio is considered to be an independent observable indicator of its research capabilities and intellectual property pool (George, Zahra, Wheatley, and Khan, 2001; Henderson and Cockburn, 1994). The greater an R&D firm's patent portfolio relative to other funded firms, the more valuable it is perceived to be, the more sought after it is, and consequently, the more PS control rights it will be guaranteed.

Hypothesis 2a. For early-stage alliances, the larger a biotechnology firm's patent portfolio at signing relative to the funded biotechnology firm with the fewest patents, the higher the percentage of PS control rights it retains.

Another factor valued by pharmaceutical firms is a biotechnology company's previous experience with R&D projects (Hoang and Rothaermel, 2005; Zollo, Reuer, and Singh, 2002). The failure rate of early-stage projects is extremely high. Partly, this is due to the fact that many biotechnology firms are startups based on the innovative ideas of one or more university researchers (Stern and Dukerich, 2006). Unfortunately, many of these ideas do not stand the test of large-scale laboratory development (Rothaermel and Deeds, 2004). R&D firms that have validated their core technologies in previous projects are thus perceived as standing a greater chance of discovering valuable new drugs than firms that have not. In addition, previous projects signal the fact that other investors have found the R&D firm to be at least a better bet than R&D firms unable to raise financing (Dessein, 2005; Leland and Pyle, 1977). Biotechnology firms with greater experience are thus more valued by pharmaceutical companies. Consequently:

Hypothesis 2b. For early-stage alliances, the greater a biotechnology firm's previous experience with R&D projects relative to the funded biotechnology firm with the least experience, the higher the percentage of PS control rights it retains.

Late-stage alliances: relative scarcity. Despite the high demand for late-stage projects by pharmaceutical firms, only 0.05% of early-stage R&D projects eventually become late-stage projects (Rothaermel and Deeds, 2004). Thus to a great extent, the few biotechnology firms that bring late-stage projects to the alliance market can choose which pharmaceutical firms to collaborate with, causing some pharmaceutical firms less prized by R&D firms to be left without late-stage projects in a given period (Sarkar, Echambadi, and Harrison, 2001). This time therefore, ∂_0 measures how valuable the best unmatched pharmaceutical firm is.

The fewer the late-stage projects in a given period, the fewer the pharmaceutical firms that are able to enter into late-stage alliances, and thus the more valuable the best unmatched pharmaceutical firm is. As we saw earlier, the greater ∂_0 is, the greater the share of PS control rights guaranteed to the scarcer partner (the R&D firm in this case). So we hypothesize:

Hypothesis 3a. For late-stage alliances, the lower the availability of late-stage R&D projects in a period, the higher the percentage of PS control rights won by each biotechnology firm.

The ability of pharmaceutical firms to win late-stage alliances depends as well on the availability of alternative funding for biotechnology firms. In early stage projects, pharmaceutical firms also act as information intermediaries, since asymmetric information prevents public investors from evaluating the prospects of biotechnology firms (Dessein, 2005; Lerner et al., 2003). However, as R&D projects advance into late-stage research, initial information problems are alleviated and biotechnology firms are likely to shift to public investors who do not demand as great a premium as pharmaceutical firms, since the latter require a return that compensates them for their investment of both financial and specialized human capital (Lerner et al., 2003).

Consequently when equity markets are more favorable, fewer biotechnology firms will bring late-stage projects to the alliance market (Lerner and Merges, 1998; Lerner et al., 2003), and fewer of the most-prized pharmaceutical firms will be able to enter into late-stage alliances. As such, the value of the best unmatched pharmaceutical firm (∂_0) rises, and each biotechnology firm entering into a late-stage alliance wins a greater share of the PS control rights.

Hypothesis 3b. For late-stage alliances, the greater the availability of alternative funding for biotechnology projects in a period, the higher the percentage of PS control rights won by each biotechnology firm.

Late-stage alliances: superior complementarity. Late-stage research projects advance beyond purely laboratory work through increasingly large-scale clinical trials, product development, repeated regulatory filings, manufacturing process development, and, ideally, full-scale manufacturing and commercialization (Blau, Pekny, Varma, and Bunch, 2004). While many pharmaceutical firms have experience and skills in these areas, most biotechnology firms do not (Rothaermel, 2001). Consequently, the knowledge and capabilities of pharmaceutical firms increase the probability of success for new drug candidates (ibid).

As pharmaceutical firms vary in their capabilities and accumulated know-how (Helfat, 1997; Henderson and Cockburn, 1994), competition remains between biotechnology firms to ally with more valuable pharmaceutical firms. The more valuable pharmaceutical firms are thus guaranteed a level of appropriation proportional to their superior complementarity (Adegbesan, 2005). A pharmaceutical firm's superior complementarity ($\Delta V_{ij} - \partial_1$) measures *how much more* value it is likely to add to a late-stage research project, than the least valuable of the pharmaceutical firms that enter into late-stage alliances. As we saw before, the greater a pharmaceutical firm's value relative to the least valuable matched pharmaceutical firm, the more PS control rights it retains.

Pharmaceutical firms that have been involved in more late-stage projects in the past are more valuable late-stage partners (Hoang and Rothaermel, 2005; Nerkar and Roberts, 2004). Over time such firms build up the complementary assets necessary for carrying out large-scale clinical trials, strong relationships with regulatory authorities, and extensive manufacturing, detailing, and distribution capabilities and infrastructure (Henderson and Cockburn, 1996; Hoang and Rothaermel, 2005). Thus pharmaceutical firms with greater experience of late-stage projects are more prized by biotechnology firms, and are consequently guaranteed more PS control rights than other pharmaceutical firms with lesser experience. As such:

Hypothesis 4a. For pharmaceutical firms entering into late-stage alliances, the greater a firm's previous experience with late-stage R&D projects relative to the pharmaceutical firm with the least experience, the higher the percentage of PS control rights it retains.

Nevertheless, knowledge of the regulatory approval and commercialization processes are not the only contributions pharmaceutical firms can make to late-stage alliances. Late-stage projects continue to require intensive ongoing research and development in response to initial clinical results, indications from regulatory authorities, and continual technological advances in the research area (Blau et al., 2004). Thus pharmaceutical firms able to contribute superior R&D expertise are more valuable in late-stage research projects (Henderson and Cockburn, 1994). In addition, research-intensive pharmaceutical firms have a larger stock of relevant scientific knowledge, as well as greater absorptive capacity for assimilating and contributing to the biotechnology firm's knowledge base (Cohen and Levinthal, 1989; George et al., 2001; Helfat, 1997). Consequently pharmaceutical firms that are more research-intensive will be more sought after by biotechnology firms.

Hypothesis 4b. For pharmaceutical firms entering late-stage alliances, the greater a firm's R&D intensity relative to the pharmaceutical firm with the lowest R&D intensity, the higher the percentage of PS control rights it retains.

Early- and late-stage alliances: relative bargaining ability. Whenever the least valuable *matched* bidding player is more valuable than the most valuable *unmatched* bidding player (i.e. $\partial_1 > \partial_0$ in Figure 1), there is a portion of the PS control rights over which partners cannot credibly threaten to exercise their strategic alternatives (Adegbesan, 2005). This portion is common to all pairs, and is split according to the relative *intra-pair* bargaining positions of alliance partners (ibid). Thus the more favorable an alliance member's bargaining position relative to its partner, the stronger its bargaining ability and the greater the share of the portion $\partial_1 - \partial_0$ it wins. As such, this residual bargaining ability reflects which partner needs the other more.

A biotechnology firm's bargaining ability is strongly influenced by how desperately it needs external financing (Lerner and Merges, 1998). Most biotechnology firms' financing projects on their own have negative cash flows, and their "survival time" is proportional to the size of their financial reserves (Lerner et al., 2003). Biotechnology firms that are closer to running out of cash are more desperate for external funding, and thus have a weaker ability to bargain over PS control rights (Higgins, 2005; Lerner and Merges, 1998). Consequently we hypothesize:

Hypothesis 5a. The lower a biotechnology firm's need for external funding, the higher the percentage of PS control rights it wins.

On the other hand, a pharmaceutical firm's bargaining ability is strongly influenced by the health of its product pipeline (Higgins, 2005; Higgins and Rodriguez, 2005). Pharmaceutical firms with static or deteriorating product pipelines will be more desperate for promising R&D projects, and thus less able to extract value from their partner (Higgins, 2005). Thus "in terms of bargaining position, [pharmaceutical] firms in this situation can be viewed as having to negotiate from a position of weakness" (ibid: 19). Consequently, we posit that the healthier a pharmaceutical firm's pipeline, the greater its bargaining ability relative to its partner, and the more PS control rights it wins.

Hypothesis 5b. The healthier a pharmaceutical firm's new product pipeline, the higher the percentage of PS control rights it wins.

Methods

Our theoretical approach suggests that intra-alliance value appropriation depends on firm-specific, group-specific, and alliance-specific factors. In order to test our theory therefore, we had to obtain rich data on each R&D alliance and each individual biotechnology/pharmaceutical firm, as well as information characteristic of the overall groups of biotechnology and pharmaceutical firms.

Data and Sample

We obtained alliance information from Recombinant Capital, a California-based consulting firm that has specialized in tracking the biotechnology industry since 1988. The firm's database is reputed to be one of the two most comprehensive publicly available data sources documenting alliance activity in the global biotechnology industry (Hoang and Rothaermel, 2005), and is typically licensed by major pharmaceutical, accounting, and law firms for a considerable annual fee (Lerner et al., 2003).

Recombinant had identified about 18,300 alliances between 1973 and 2006, from securities filings with federal and state authorities, news accounts, and press releases (Recombinant Capital, 2006). It provides summaries for about 13,000 alliances, detailed analyses for about 1,300 alliances, and over 5,000 actual alliance contracts (ibid). Since Recombinant updates its database with subsequent filings and new information over time, we chose to focus on alliances that were initiated between 1993 and 2000, giving a five-year time frame (i.e. 2001-2006) for the identification of material information, while focusing on R&D projects that are not too far removed in time from current developments in the industry.

As of January 2006, Recombinant had identified 2,173 alliances between pharmaceutical and biotechnology firms that took place between 1993 and 2000, and which involved a license. Of these we randomly selected 180 alliances for which detailed analyses and contract information were available,⁴ as follows:

We started by randomly selecting 160 alliances. Based on our theoretical model, we excluded alliances where:

⁴ "The choice of which alliances to analyze by Recombinant may not be random. Their selection procedure was described by an employee as follows: 'The first criterion is that the deal contracts are available. For that to happen, one of the two parties has to publicly trade stock in the US and the alliance has to be material to the company. For the deal to be material, it should comprise about 10 percent of a company's annual revenue or 5 percent of its asset value. We find contracts for about 40 percent of the deals. As we find deal contracts, those that are considered interesting or important are put into a queue to be analyzed. The really big deals are no-brainers, but I think interesting deals or deals that illustrate or typify current trends are also chosen. On top of that, we analyze deals as part of our consulting practice. Web and consulting clients ask us to analyze particular deals that then become part of our collection. Also, analysts sometimes analyze a bunch of related deals as part of a research project to answer a specific question. All told, one in ten deals is analyzed'" (Higgins, 2005: 13).

- One of the parties was a government agency, a non-profit organization, or a university;
- Both firms were biotechnology or pharmaceutical firms;
- There existed no research component or aspect to the alliance (e.g. a purely manufacturing or distribution alliance);
- One firm had a controlling interest in the other firm;
- There were more than two partners in the alliance;
- The pharmaceutical firm was carrying out R&D on behalf of the biotechnology firm.

Following Lerner et al. (2003), we eliminated alliances that violated one or more of our criteria, replacing them with another random draw. We then examined the 160 resulting alliances to identify the stage in the regulatory approval process at which the agreement was signed. Following previous research, alliances pursuing molecule discovery, lead molecule development or pre-clinical development were coded as “Early-stage” alliances, while those in clinical testing or undergoing regulatory review were coded as “Late-stage” alliances.

As expected, the great majority of the alliances (73%) were early-stage projects. Therefore in order to obtain a sample size sufficient for testing our late-stage hypotheses, we randomly drew 20 more late-stage alliances (again following Lerner et al.’s selection procedure) to bring our sample to 64 late-stage alliances and 116 early-stage alliances, for a total sample size of 180. To avoid biasing our sample in an unpredictable way, we used only the original 160 alliances for tests on the overall sample, reserving the 20 additional alliances for tests of late-stage hypotheses.

For each alliance, we extracted information including: the date and length of the alliance, the technology and subject covered, total value, up-front payments, royalty rates, contingent or milestone payments, and R&D payments. In addition, we carried out an in-depth content analysis of each contract to identify the allocation of various control rights, the presence and amount of royalties, and equity purchases among other issues. Our contract analysis also enabled us to verify (and in a few cases, correct) information reported in the alliance summaries.

Having constructed the deal-level data, we then proceeded to supplement it with data on each of the identified firms and groups, to construct our dependent and independent variables. As further discussed below, our sources included the U.S. Patent and Trademark Office and the National Bureau of Economic Research patent databases (biotechnology firm patents), the Compustat Global Issue and the Research Insight databases (firm financial data), the Securities Data Corporation (biotechnology IPO data), the FDA Orange Book (pharmaceutical patent profiles and marketing exclusivity), and the IMS Health database (pharmaceutical patented drug sales).

Dependent Variable

To identify which control rights were “pie-splitting,” we combined an extensive review of literature on biotechnology R&D alliances and alliance contractual design with input from industry practitioners, including the head of alliance management at one of the top-ten global pharmaceutical firms. Our detailed analysis of each agreement also gave us an important sense of which rights depended more on firm bargaining position than, say, efficient task assignment, or protection against potential opportunistic behavior. For example, the right to management of

clinical trials is highly coveted by both biotechnology and pharmaceutical firms. However, we did not include this right as a *pie-splitting* right because it is more related to the ability to determine the course of the collaboration, than the division of returns to such a partnership. In other words, while non-PS control rights can be very valuable to both partners, we focus here on PS control rights, as a result of our interest in how value is *split* as opposed to the undeniably related issue of how it is *created*.

Our PS control rights are composed of the following 10 “slices,” described in more detail in the Appendix:

- Intellectual Property Rights
 1. Partial patent ownership
 2. Exclusive patent ownership
 3. Right to transfer of unpatented “know-how”
 4. Ownership of unpatented “know-how”
- Licensing Rights
 5. Right to sublicense
 6. Continued licensing rights on *expiration*
- Manufacturing Rights
 7. Right to manufacture final product
- Marketing Rights
 8. Basic marketing rights
 9. Universal marketing rights
 10. Control of entire marketing process

We carried out a detailed analysis of 56 contractual terms identified by Recombinant Capital in each alliance agreement, to extract the allocation of these PS control rights. Following previous literature, we adopted the convention of coding the rights allocation from the point of view of the pharmaceutical firm (“1” if assigned to the pharmaceutical firm, “0” if assigned to the biotechnology firm or “N/A” – not allocated).

In order to relate our results to previous work, we also identified: the 25 control rights used by Lerner and Merges (1998); the 5 control rights used by Lerner et al. (2003); and the 10 control rights used by Higgins (2005). As highlighted in the Appendix, our PS control rights comprise a subset of Lerner and Merges’ 25 rights (8 of them), 1 control right unidentified by Lerner and Merges which Higgins uses, and 1 final PS right which was identified in conversations with practitioners.

We counted the number of PS control rights allocated in each agreement, and following our coding convention, we calculated the percentage of such rights won by the pharmaceutical firm. This latter variable (*pharmaPS percentage*) is the principal dependent variable used in this study. However, we also explore a number of secondary dependent variables to check the robustness of our results.

Firstly we consider the “royalty split” between alliance partners.⁵ Royalty splits have the strong advantage of being an explicit value-sharing measure, but they also have the disadvantage of not telling the whole story of surplus division on their own. For example, a partner may sometimes trade a reduced share of the royalty split (or none at all) for, say, co-promotion rights, or exclusive patent ownership. In addition, royalty splits may partly serve to compensate for costs incurred by one partner on behalf of the alliance. As such, royalties are not always purely a mechanism for sharing surplus (which is what our theory predicts). Finally, although many biotechnology R&D alliances include royalty terms, the majority of such terms are confidential, making it difficult to obtain royalty data. Despite these difficulties, however, looking at PS control right splits combined with royalty splits should give a good picture of value appropriation.

We were able to extract royalty data for 61 of the deals in our sample (34%). By subtracting the percentage royalty paid from 100%, we generated the variable *pharmaRoyalty percentage*, which we use in some of our regressions.

Finally, to compare our principal dependent variable with other measures, we include analyses where the dependent variable is a simple count of the PS control rights won by the pharmaceutical firm (*pharmaPS count*); the count of 25 control rights used by Lerner and Merges (*pharmaL&M count*); and the count of 5 rights used by Lerner, Shane, and Tsai (*pharmaLS&T count*).

Explanatory Variables

We measured the availability of pharmaceutical funding with the variable *pharmaceutical funding*, which captures the annual amount pharmaceutical firms spent on biotechnology R&D alliances in billions of dollars (see Table 1 for definitions of all the variables used in this study). We obtained these figures from a Recombinant database which tracks trends in alliance financing.

The availability of alternative funding for biotechnology projects was captured by the total amount raised in biotechnology IPOs in the previous year. The data for this variable (*previous IPO*) was obtained from Thomson Financial’s Securities Data Corporation database in billions of dollars.

We tracked the availability of late-stage projects by means of two related variables. Firstly, we recorded the number of late stage projects in each period as the variable *lateStage number*. Secondly, we calculated the percentage of projects over a period that were late-stage projects, and stored this value as the variable *lateStage percentage*.

⁵ Strictly speaking, royalties are paid by only one partner. However, in line with our interest in value appropriation, we consider the amount “retained” from royalty payments, as the paying partner’s share of the royalty split. In other words, if for example a pharmaceutical firm pays 25% on sales as a royalty, we consider it as having “retained” 75% of the royalty split.

Table 1

Variables and Definitions

Variable	Definition
<i>PharmaPS percentage</i>	Percentage of “pie splitting” rights allocated to the pharmaceutical firm
<i>EarlyStage</i>	Dummy = 1 if stage is molecule discovery, lead molecule development or pre-clinical development
<i>LateStage</i>	Dummy = 1 if stage is clinical testing or beyond
<i>Previous IPO</i>	Total biotech IPO funds raised in previous year, billions of dollars
<i>Pharmaceutical funding</i>	Annual spending on biotechnology R&D alliances, billions of dollars
<i>LateStage number</i>	Number of late-stage projects
<i>LateStage percentage</i>	Percentage of projects in a period that are late-stage
<i>Superior pharma late-project experience</i>	Measure of firm experience with late-stage projects relative to least experienced firms for each period
<i>Superior pharma R&D intensity</i>	R&D intensity of firms involved in late-stage projects divided by firm with the lowest R&D intensity
<i>Pharma pipeline score</i>	Measure of firm level research pipeline health
<i>Pharma market cap</i>	Pharmaceutical firm market capitalization, millions of dollars
<i>Superior biotech project experience</i>	Number of previous early-stage projects for each firm minus the lowest number of previous early-stage projects for each period
<i>Biotech shareholders equity</i>	Biotechnology firm shareholder equity, millions of dollars
<i>Survival years</i>	Firm’s financial resources at end of previous year divided by negative of net income (firms with positive net income are coded as infinite survival time)
<i>RoyaltyPresent</i>	Dummy = 1 if royalty provision is present in contract
<i>EquityInvolved</i>	Dummy = 1 if equity allocation or purchase is present in contract
<i>DealSize</i>	Total value of alliance payments, millions of dollars
<i>PharmaPS count</i>	Count of the “pie-splitting” controls allocated to pharmaceutical firm
<i>PharmaL&M count</i>	Count of 25 control rights used by Lerner and Merges (1998)
<i>PharmaLS&T count</i>	Count of 5 control rights used by Lerner <i>et al.</i> (2003)

By searching the Recombinant database we identified previous biotechnology R&D alliances for each firm in our sample, as at the signing of each current alliance. For each year, we then identified the allying firms with the *least* previous early- and late-stage projects. Using this data, we constructed variables for Hypotheses 2b and 4a as follows:

By subtracting the number of previous projects carried out by the early-stage biotechnology firm with the lowest number in each period from the number carried out by each other early-stage firm in that period, we created the variable *superior biotech project experience*. This variable measures how much greater a biotechnology firm's previous experience with R&D projects is, relative to the funded biotechnology firm with the least experience.

In a similar fashion, but focusing on pharmaceutical firms in late-stage projects, we generated the variable *superior pharma late-project experience* which measures how much greater a pharmaceutical firm's previous experience with late-stage projects is, relative to the firm with the least experience.

We obtained financial information for both pharmaceutical and biotechnology firms primarily from Research Insight. Using this source we calculated the R&D intensity for each pharmaceutical firm involved in a late-stage alliance in each period. By dividing this figure by the value for the corresponding firm with the lowest R&D intensity, we obtained the variable *superior pharma R&D intensity*, for testing Hypothesis 4b.

The biotechnology firm's need for external funding was captured in two ways. Firstly we used the size of its shareholder's equity (*biotech shareholders equity*) in millions of dollars. Secondly we calculated the number of years a biotechnology firm could continue losing money without seeking additional financing or cutting back on its research activities (Lerner et al., 2003). As such the variable *survival years* is obtained by dividing the firm's financial resources at the end of the previous year (cash, short-term assets, long-term liquid assets, cash equivalents, and marketable securities) by the negative of its net income in the previous year. The very few biotechnology firms with positive net income⁶ were coded as having infinite survival time (ibid).

Finally the health of each pharmaceutical firm's pipeline was obtained using data from the (US) Food and Drug Administration's *Orange Book*. For each pharmaceutical firm in each year, we identified the number of projects it had at each stage of the regulatory approval process. We then weighted the number of projects at each stage using probabilities that they would end up as successful drugs from Krieger and Ruback (2001). We summed these weighted counts to generate a measure of pharmaceutical pipeline health called *pharma pipeline score* (Higgins and Rodriguez, 2005). We also captured the growth (positive or negative) in each firm's pipeline from the previous year (*pharma pipeline growth*). Both variables gave similar results and so we use *pharma pipeline score*.

Control Variables

Our analysis of the alliance agreements enabled us to detect the presence of royalty payments (*royaltyPresent*), and equity allocations/purchases (*equityInvolved*) for each deal. It also suggested that royalties or/and equity sometimes substitute for PS control rights allocation, and so we sought to separate any effects they might have from those of our explanatory variables.

⁶ 92% of the biotechnology firms in our sample were losing money.

We also control for the total value of alliance payments (*dealSize*) and the pharmaceutical firm's market capitalization (*pharma market cap*). These enable us to detect whether pharmaceutical firms simply pay for PS control rights, and whether their ability to win PS control rights is a function of their size. While *dealSize* is obtained from Recombinant Capital (millions of dollars), most market capitalization data was obtained from Research Insight (billions of dollars). For non-US pharmaceutical firms, share price data and shares outstanding were obtained from Compustat Global Issue database, and other currencies were converted to US dollars using Compustat Global Currency database with 12 month average exchange rates.

Finally, since pharmaceutical funding is applied to both early- and late-stage projects, we control for the availability of late-stage projects when we perform early-stage regressions where pharmaceutical funding is one of the explanatory variables. Similarly, we control for total pharmaceutical funding when we perform late-stage regressions where the availability of alternative funding is one of the explanatory variables.

Estimation Procedure

Due to the fact that we had fractional dependent variables, we could not employ ordinary linear regression without implicitly imposing arbitrary limits on the range of variation in our independent variables (Papke and Wooldridge, 1996). We therefore followed the standard procedure of logistic transformation employing maximum likelihood estimation. This was implemented using *Stata's* "Generalized Linear Models" function, which is specifically enhanced to tackle fractional response variables. For the regressions involving count dependent variables (*pharmaPS count*, *pharmaL&M count*, and *pharmaLS&T count*) we employed ordered logit models.

Analysis and Results

Table 2 shows descriptive statistics and bi-variate correlations for our variables. As can be seen from the table, the average pharmaceutical firm in our sample had a market capitalization of \$51 billion⁷ and a weighted new product pipeline score of 257 (median of 166). It had been involved in 12 late-stage alliances prior to the focal alliance, and it had an R&D intensity of 12%. Furthermore, the typical late-stage pharmaceutical firm had been involved in ten more late-stage projects than the marginal late-stage pharmaceutical firm, and it had R&D intensity 1.9 times that of the marginal pharmaceutical firm.

Meanwhile, the average biotechnology firm had been involved in 20 previous R&D alliances (median of 14), had a shareholder equity value of \$76 million, and would run out of money in three years at its current rate of cash burn. The mean early-stage biotechnology firm had been involved in 17 more R&D alliances than the marginal early-stage biotechnology firm.

The average alliance in our sample was valued at \$65 million. 73% of the alliances were early-stage alliances, 91% of them included royalty terms, and 53% involved equity purchase or allocation. Out of our ten PS control rights, at least nine of them were explicitly allocated between alliance partners in 92% of the deals, further underlining their importance. The average pharmaceutical firm won 67% of the PS rights, while the average biotechnology firm received a royalty payment of 28%.

⁷ All financial values are in constant (year) 2000 dollars.

Finally, the time period spanned by our sample was characterized by average annual pharmaceutical spending on biotechnology alliances of \$1.1 billion, following on average biotechnology IPO funding of \$4.8 billion in the previous year. The average number of late-stage alliances launched each year was 40, representing an average of 15% of the biotechnology R&D alliances.⁸

Although none of the bi-variate correlations in Table 2 exceeded the recommended ceiling of 0.7, we noted some relatively high correlations, due to a number of complex relationships, some of which go beyond the scope of this paper. (For instance, a healthy product pipeline may be related to previous alliances, and indicates future earning potential, which should in turn be reflected in a firm's market valuation. Similarly, the availability of late-stage projects simultaneously affects and is affected by the availability of both pharmaceutical funding and public equity financing).

Therefore, in order to find out whether the correlations adversely affected the independent variation in each of our measures, we computed variance inflation factors for all our variables in all our analyses. We found that in no case were they up to the recommended ceiling of ten (Kleinbaum, Kupper, and Muller, 1988), and the mean variance inflation factor was less than four. We were thus confident that regression would be able to discriminate between the independent and shared variation in our sample variables.

Overall Sample

The first regressions reported in Table 3 explore the variation in control rights allocation over the entire sample, using three different dependent variables: *pharmaPS percentage* (our principal variable of interest), *pharmaPS count*, and *pharmaLS&T count*.

Perhaps the most striking feature of Model 1 (*pharmaPS percentage*) is the pronounced effect of the presence of royalty payments on the allocation of PS control rights across both early- and late-stage alliances. The variable *royaltyPresent* is very significant ($p < .001$), accounting for a large part of variation in the share of PS control rights won by the pharmaceutical firm. Thus we see that pharmaceutical firms win a larger share of PS control rights when they pay royalties. This would seem to suggest that they are willing to pay royalties in return for more PS control rights, supporting our view of PS control rights as another mechanism for "splitting the pie." This is also supported by the fact that *royaltyPresent* is barely significant when predicting a count of "important" (Lerner et al., 2003) control rights that are not pie-splitting (Model 2).

⁸ In spite of the dramatic growth in R&D alliances over the period, the number of late-stage alliances held relatively steady, with a consequent fall in the percentage of late-stage alliances over the period.

Table 2

Descriptive Statistics and Correlations

Variable	Mean	s.d.	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1. PharmaPS percentage	0.67	0.13	0.25	0.90																
2. EarlyStage	0.73	0.45	0.00	1.00	0.24															
3. Previous IPO	4.79	2.00	2.20	8.50	0.07	-0.03														
4. Pharmaceutical funding	1.13	0.48	0.42	1.75	0.10	-0.13	0.59													
5. LateStage number	40.17	10.07	20.00	52.00	0.11	-0.14	0.08	0.44												
6. LateStage percentage	0.15	0.02	0.10	0.19	-0.02	-0.06	-0.35	-0.33	0.64											
7. Superior pharma late-project experience	10.64	8.70	0.00	31.00	0.31	-0.05	0.06	0.37	0.36	-0.01										
8. Superior pharma R&D intensity	1.93	0.79	1.00	4.55	-0.04	-0.01	0.17	0.57	-0.06	-0.43	-0.09									
9. Pharma pipeline score	256.87	285.43	8.60	1,325.80	0.10	-0.04	0.26	0.55	0.03	-0.40	0.49	0.36								
10. Pharma market cap	50.69	43.96	0.10	216.00	0.19	-0.06	0.38	0.56	0.15	-0.30	0.66	0.04	0.61							
11. Superior biotech project experience	17.32	18.82	0.00	121.00	-0.10	0.06	0.11	0.32	0.09	-0.24	-0.01	0.22	0.21	-0.01						
12. Biotech shareholders equity	76.96	153.30	0.30	1,462.30	-0.03	0.02	0.14	0.20	-0.07	-0.23	-0.06	-0.05	0.35	0.09	0.64					
13. Survival years	3.12	4.08	0.10	22.80	0.11	0.00	0.04	-0.02	-0.06	-0.09	0.11	-0.34	0.08	0.04	0.17	0.22				
14. Royalty/Present	0.91	0.28	0.00	1.00	0.21	-0.02	0.05	0.10	0.28	0.18	0.11	0.10	0.00	0.09	0.06	0.03	0.03			
15. DealSize	65.06	95.19	1.50	815.00	-0.12	-0.14	0.14	0.33	0.09	-0.17	0.10	0.32	0.42	0.17	0.52	0.47	0.08	0.04		
16. EquityInvolved	0.53	0.50	0.00	1.00	-0.10	-0.04	-0.27	-0.22	-0.07	0.08	0.05	0.09	-0.27	-0.26	-0.14	-0.10	-0.18	0.04	0.04	-0.01

n = 180

Table 3

Results of Regression Analyses for Overall Sample^a

Independent Variables	Model 1: PharmaPS percentage (GLM ^b)	Model 2: PharmaLS&T count (Ordered Logit)	Model 3: PharmaPS count (Ordered Logit)	Model 4: PharmaRoyalty percentage (GLM)
Constant	0.42 (0.46)			-1.39 (1.25)
EarlyStage	0.29** (0.10)	1.12* (0.44)	0.91* (0.41)	0.70** (0.23)
Previous IPO	0.01 (0.03)	0.10 (0.14)	-0.01 (0.12)	0.11* (0.06)
Pharmaceutical funding	-0.20 (0.26)	-0.07 (0.99)	0.47 (1.11)	-1.53* (0.59)
LateStage number	0.01 (0.01)	-0.01 (0.05)	-0.02 (0.05)	0.03 (0.03)
LateStage percentage	-4.48 (4.19)	3.13 (18.42)	5.62 (17.22)	1.31 (11.33)
Superior pharma late-project experience	0.03*** (0.01)	0.06* (0.03)	0.11*** (0.03)	2.53E-03 (0.01)
Superior pharma R&D intensity	-0.07 (0.06)	0.08 (0.23)	-0.21 (0.25)	0.30* (0.13)
Pharma pipeline score	-7.18E-05 (2.14E-04)	-6.65E-04 (9.31E-04)	-4.00E-04 (7.78E-04)	5.78E-05 (4.97E-04)
Pharma market cap	-1.54E-03 (1.44E-03)	9.62E-04 (0.01)	-0.01 (0.01)	0.01*** (3.61E-03)
Superior biotech project experience	0.01* (2.75E-03)	0.02* (0.01)	0.02* (0.01)	0.02** (0.01)
Biotech shareholders equity	-8.61E-04** (3.11E-04)	-3.56E-03** (1.13E-03)	-3.41E-03** (1.13E-03)	-6.25E-04 (1.55E-03)
Survival years	0.01 (0.01)	0.08 (0.07)	0.04 (0.05)	0.03 (0.03)
RoyaltyPresent	0.51*** (0.12)	1.25* (0.67)	2.46*** (0.65)	
EquityInvolved	-0.14 (0.09)	-0.45 (0.41)	-0.40 (0.35)	0.04 (0.22)
Log pseudo-likelihood	-51.14	-178.46	-178.29	-19.27

^a Robust standard errors are in parentheses

^b Generalized Linear Model (utilizing a Bernoulli variance function and a Logit link function)

+ p < .10

* p < .05

** p < .01

*** p < .001

The variable *earlyStage* is also very significant ($p < .01$) with a positive coefficient, indicating that pharmaceutical firms generally win more PS control rights in early-stage alliances than in late-stage ones. This is in line with our theory that pharmaceutical firms are in a weaker bargaining position in late-stage projects due to the scarcity of such projects, and the increased funding options of the biotechnology firms. This effect holds across Models 1-4, supporting our approach of considering the market for biotechnology R&D alliance partners as consisting of two sub-markets corresponding to early- and late-stage partners. We also find a significant ($p < .01$) negative effect of biotechnology shareholders' equity, thus replicating findings from previous work (Higgins, 2005; Lerner and Merges, 1998). Finally, as should be expected, our theoretically-derived explanatory variables are more significant in predicting our principal dependent variable (Model 1) than in predicting alternative measures of value appropriation (Models 2 and 3).

Early-Stage Alliances

The results in Table 4 (Model 5) explore the allocation of PS control rights in early-stage markets. Hypothesis 1 predicted that the lower the availability of pharmaceutical funding, the larger the share of PS control rights won by each pharmaceutical firm. We find that *pharmaceutical funding* is negative and significant ($p < .01$), thus supporting Hypothesis 1.

We also find support for our hypotheses on the effect of superior complementarity. The variable *superior biotech project experience* is negative and significant ($p < .05$) suggesting that biotechnology firms with superior experience win more PS control rights from their pharmaceutical partner, thus supporting Hypothesis 2b. However we do not find support for the hypotheses on relative bargaining ability (Hypotheses 5a and 5b). This could mean that bargaining over PS control rights in early-stage alliances is driven more by scarcity of pharmaceutical funding, and relative complementarity of individual biotechnology firms, than the desperation and bargaining skill of individual alliance partners.

With respect to our control variables, although *royaltyPresent* is now less significant ($p < .1$) its positive sign continues to suggest that PS rights are a substitute value appropriation mechanism that can compensate for royalty payments. On the other hand, *dealSize* and *equityInvolved* are not significant predictors of value appropriation in early-stage alliances. However, our control for the availability of late-stage projects is significant ($p < .01$), providing further indirect support for Hypothesis 1.

Specifically, for a given level of pharmaceutical funding, since pharmaceutical firms will preferentially fund late-stage projects, we would expect that if the number of late-stage alliances increased, some funding would be shifted from early- to late-stage projects, thus increasing the scarcity of funding for early-stage projects, and consequently increasing the share of PS rights won by each pharmaceutical firm (Hypothesis 1). For this reason, the positive coefficient on *lateStage number* is consistent with this hypothesis. Similarly, we would expect that for a given funding level and number of late-stage alliances, an increase in the percentage of projects in later stages can only come about through a decrease in the number of early-stage projects, reducing the relative scarcity of pharmaceutical funding, and thus favoring biotechnology firms. As such, the negative coefficient on *lateStage percentage* is consistent with this position as well. Thus our control for the availability of late-stage projects provides additional indirect support for Hypothesis 1.

Table 4

Results of Regression Analyses for Early-Stage Alliances^a

Independent Variables	Model 5: PharmaPS percentage (GLM ^b)	Model 6: PharmaLS&T count (Ordered Logit)	Model 7: PharmaL&M count (Ordered Logit)	Model 8: PharmaPS count (Ordered Logit)	Model 9: PharmaRoyalty percentage (GLM)
Constant	2.11*** (0.60)				4.03 (3.57)
Pharmaceutical funding	-0.62** (0.23)	0.70 (1.36)	-0.40 (1.13)	-0.91 (1.06)	-1.12 (1.20)
Superior biotech project experience	-0.01* (3.39E-03)	-0.02 (0.02)	-0.02 (0.02)	-0.02 (0.02)	-0.01 (0.02)
Biotech shareholders equity	-2.16E-05 (2.98E-04)	-2.99E-03* (1.23E-03)	-2.48E-03* (1.20E-03)	-1.12E-03 (1.08E-03)	-9.10E-04 (2.43E-03)
Survival years	-0.01 (0.01)	0.03 (0.07)	0.02 (0.04)	-0.03 (0.05)	-0.06 (0.08)
Pharma pipeline score	5.61E-04 (3.99E-04)	2.26E-04 (2.34E-03)	2.52E-03 (2.03E-03)	3.02E-03 (2.18E-03)	2.95E-04 (1.78E-03)
Pharma pipeline growth	-4.49E-04 (5.81E-04)	-8.38E-04 (3.12E-03)	-2.16E-03 (2.40E-03)	-3.30E-03 (2.76E-03)	-2.26E-04 (2.21E-03)
RoyaltyPresent	0.24* (0.13)	1.27 (0.93)	1.65 (1.17)	1.60* (0.96)	3.12E-03 (1.03E-02)
DealSize	1.07E-04 (3.27E-04)	2.79E-03 (2.48E-03)	2.53E-03* (1.52E-03)	6.40E-04 (1.38E-03)	-0.32 (0.54)
EquityInvolved	-0.18 (0.12)	-0.20 (0.56)	1.37* (0.57)	-0.25 (0.51)	0.09 (0.06)
LateStage number	0.04** (0.01)	0.05 (0.06)	0.04 (0.06)	0.10* (0.05)	0.09 (0.06)
LateStage percentage	-16.58** (5.07)	-33.41 (23.76)	-21.40 (25.74)	-37.81* (21.82)	-30.90 (27.14)
Log pseudo-likelihood	-32.44	-106.59	-159.39	-108.72	-9.97

^a Robust standard errors are in parentheses

^b Generalized Linear Model (utilizing a Bernoulli variance function and a Logit link function)

+ p < .10

* p < .05

** p < .01

*** p < .001

Finally, we also note that when we change our dependent variable to a simple count of undifferentiated control rights (Model 7: Lerner and Merges, 1998), a count of important control rights (Model 6: Lerner, Shane, and Tsai, 2003), or even a count of PS control rights (Model 8), several of our independent variables lose significance or become marginally significant.

Late-Stage Alliances

Table 5 (Model 10) reports results for the analysis of bargaining over PS control rights in late-stage markets. As can be seen from Model 10, our hypotheses on the impact of relative scarcity are supported. *LateStage percentage* is positive and significant ($p < .01$), thus supporting Hypothesis 3a which predicted that increased availability of late-stage projects would favor pharmaceutical firms. Similarly, Hypothesis 3b is supported by the fact that *previous IPO* is negative and significant ($p < .05$), suggesting that increased availability of alternative funding favors biotechnology firms.

Hypothesis 4a is supported by the fact that *superior pharma late-project experience* is positive and significant ($p < .05$), suggesting the importance of superior complementarity. However, we do not find support for Hypothesis 4b, as *superior pharma R&D intensity* is not significant.

We also have mixed results for the impact of bargaining ability (Hypotheses 5a and 5b). While *biotech shareholders equity* is not significant, *pharma pipeline score* is significant ($p < .05$), but has a sign opposite to the prediction of Hypothesis 5b. Another variable (*lateStage number*) is also significant ($p < .01$) but opposite in sign to our prediction (Hypothesis 3a).

With respect to our control variables, *royaltyPresent* again has a strong significance ($p < .01$) suggesting biotechnology firms may be willing to give up royalties in exchange for a greater share of PS control rights. We also find a significant increase ($p < .001$) in the share of PS control rights won by biotechnology firms in larger late-stage deals (*dealSize* is negative). Since average *dealSize* grows as projects advance in the regulatory approval process, like Higgins (2005: 29), we interpret this finding in terms pharmaceutical firms' preference for later-stage projects. This is also supported by the fact that *dealSize* is not significant in early-stage alliances (Model 5).

Additionally, as before, we note that when we change our dependent variable to counts of Lerner et al. and Lerner and Merges' control rights (Models 11 and 12 respectively), most of our significant independent variables become insignificant, while the rest become less significant.

One final point worthy of note is that Models 4, 9, and 14 capture the impact of our explanatory variables on each alliance's royalty split, mainly for illustrative reasons. Overall, they seem to support our position that with PS control rights we are predicting the split of a construct related to performance. However, these results are far from conclusive, due to the complex relationship between PS control rights and royalty payments. While the two constructs are certainly related (e.g. as suggested by the variable *royaltyPresent* throughout our analyses), we would need more detailed information on firm preferences and costs to elucidate the relationship between the two. Overall, however, our results seem to us to suggest the importance of relative scarcity, superior complementarity, and relative bargaining ability in winning PS control rights, and thus in intra-alliance value appropriation.

Table 5

Results of Regression Analyses for Late-Stage Alliances^a

Independent Variables	Model 10: PharmaPS percentage (GLM ^b)	Model 11: PharmaL&M count (Ordered Logit)	Model 12: PharmaS&T count (Ordered Logit)	Model 13: PharmaPS count (Ordered Logit)	Model 14: PharmaRoyalty percentage (GLM)
Constant	-1.96** (0.62)				-3.05* (1.30)
Previous IPO	-0.11* (0.05)	-0.06 (0.30)	-0.50 (0.34)	-0.61+ (0.32)	0.18** (0.06)
LateStage number	-0.05** (0.02)	0.03 (0.09)	0.14 (0.19)	-0.29* (0.12)	-0.02 (0.03)
LateStage percentage	19.19** (5.99)	45.53 (34.79)	-50.78 (56.79)	114.68* (49.21)	22.15* (12.33)
Superior pharma late-project experience	0.02* (0.01)	0.04 (0.05)	0.20** (0.07)	0.14* (0.06)	-4.83E-03 (1.57E-02)
Superior pharma R&D intensity	-0.01 (0.13)	0.22 (0.45)	0.52 (0.97)	-0.35 (0.64)	0.08 (0.12)
Pharma pipeline score	-8.43E-04* (3.88E-04)	-1.53E-03 (1.50E-03)	-5.07E-03* (2.36E-03)	-4.66E-03* (2.02E-03)	8.68E-04* (4.17E-04)
Pharma market cap	3.25E-03* (1.83E-03)	2.81E-03 (1.23E-02)	0.01 (0.01)	0.01 (0.01)	3.11E-03 (3.40E-03)
Biotech shareholders equity	-5.41E-04 (8.69E-04)	5.25E-03 (4.43E-03)	-0.01 (0.01)	-2.84E-03 (4.28E-03)	6.79E-04 (1.11E-03)
Biotech previous projects	0.01* (0.01)	0.04* (0.02)	0.08* (0.03)	0.06* (0.03)	0.02** (0.01)
RoyaltyPresent	0.49** (0.15)	0.60 (0.90)	2.69* (1.14)	3.29* (1.40)	-1.34E-03 (1.54E-03)
DealSize	-3.45E-03*** (8.52E-04)	-0.02** (0.01)	-3.07E-03 (4.11E-03)	-0.02** (0.01)	0.50* (0.25)
EquityInvolved	0.15 (0.14)	-0.81 (1.03)	-0.34 (0.88)	0.45 (0.84)	-0.77* (0.46)
Pharmaceutical funding	1.28** (0.39)	1.04 (1.66)	-2.02 (3.15)	7.80** (2.92)	
Log pseudo-likelihood	-16.99	-50.99	-69.37	-49.19	-9.32

^a Robust standard errors are in parentheses

^b Generalized Linear Model (utilizing a Bernoulli variance function and a Logit link function)

+ p < .10

* p < .05

** p < .01

*** p < .001

Discussion

We started this paper by asking what determines how the value created by an alliance is shared between its members, and we have attempted to address the question in two steps.

Firstly, we suggested that the *ex ante* distribution of returns to alliance activity could be proxied by the distribution of control over activities and decisions that directly affect the allocation of portions of the overall value to be created by an alliance. When alliance outcomes are uncertain, the allocation of “pie-splitting” control rights assures partners of value appropriation in the event that the alliance is successful. In this way, firms can work around the otherwise heroic demands of information and time required for bargaining over (possible) future returns in multiple alliances involving multiple partners. Specifically, in the context of biotechnology R&D alliances, we proposed a subset of ten PS control rights distilled from extant literature and validated by means of in-depth contractual analysis and input from practitioners.

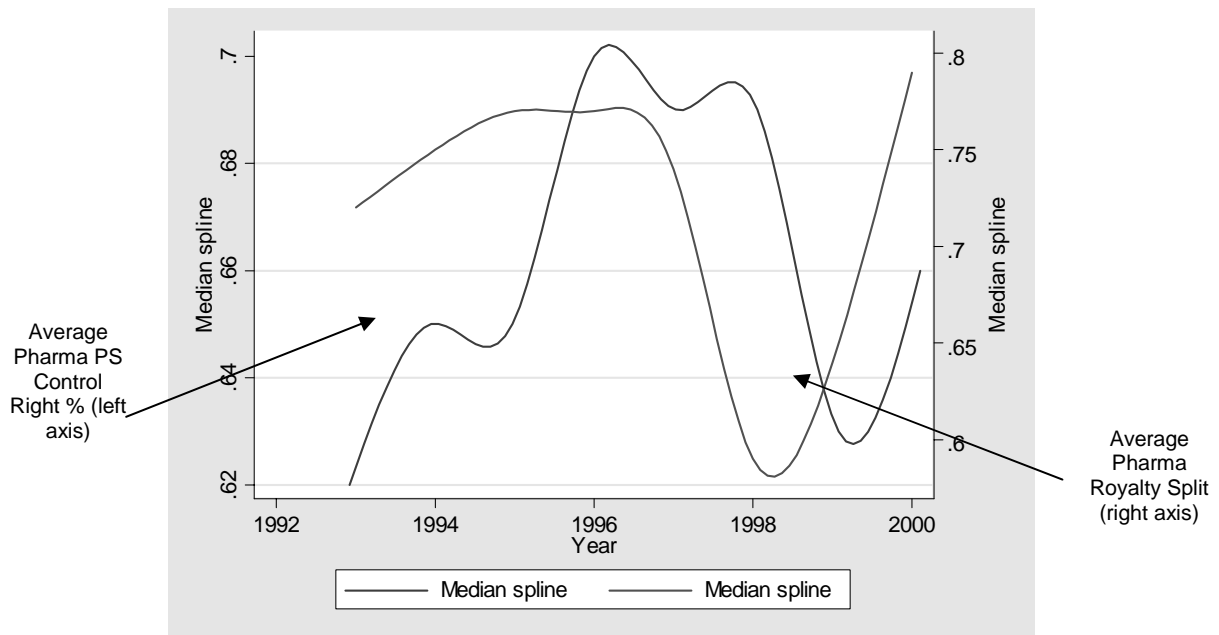
In support of our position, our results suggest that a greater share of PS control rights acts as a substitute for an improved royalty split, while the sharing of PS control rights was nicely predicted by variables intuitively related to firm performance. The *split* of PS control rights also seemed to track performance more accurately than a count of overall control rights, a count of important control rights, or even a simple count of PS control rights themselves. Finally, although the relationship between royalty splits and PS control right splits is undoubtedly a complex one, some of our results suggest that they vary in a similar way over time. Thus, as Figure 3 shows for example, the split of PS control rights seems to lag the royalty split over time. Nevertheless, time is obviously only one dimension along which these two variables may be related.

In a second step, we proposed that since many types of alliances can be conceptualized as taking place in strategic factor markets where potential partners vary in their complementarity to one another (Barney, 1986; Sarkar et al., 2001; Thomke and Kuemmerle, 2002), the *ex ante* distribution of returns to individual partners in such alliances could be predicted by an extension of strategic factor market theory proposed by Adegbesan (2005). Applying the model to biotechnology R&D alliances we measured relative scarcity, relative bargaining ability, and superior complementarity in terms of firm-level and group-level variables, which we then used to predict inter-group, intra-group, and intra-pair variation in value appropriation. Furthermore, in doing so, our theory led us to decompose the alliance market into two sub-markets corresponding to early- and late-stage alliances.

In support of our position, our results show strong support for the structural distinction between early- and late-stage markets. Thus we lend support to Higgins' (2005) finding that the bargaining position of *both* pharmaceutical and biotechnology firms is important, while also providing an explanation for empirical work that has found bargaining power “supplanting” efficiency in the allocation of control rights (in violation of the predictions of the property rights literature).

Figure 3

PS Control Rights Split vs. Royalty Split



Our findings also suggest a strong impact of relative scarcity and superior complementarity in both early- and late-stage markets. With respect to scarcity, in early-stage alliances, biotechnology firms gave up PS control rights when pharmaceutical funding was less available, while in late-stage alliances pharmaceutical firms gave up PS control rights when late-stage projects were less available. Nevertheless, firm-specific superior complementarity allowed some partners to improve their value appropriation even in the face of unfavorable scarcity effects. As such, in early-stage alliances, biotechnology firms with superior project experience retained more PS control rights, and in late-stage alliances pharmaceutical firms with superior late-stage experience retained more PS control rights.

The importance of firm-specific resources and capabilities is very interesting given the growing impact of group-level variables over the period spanned by our sample. For example, as shown in Figure 4, the number of R&D alliances has greatly increased over time, while the average percentage of PS control rights won by biotechnology firms in early-stage alliances has been falling. Thus superior complementarity becomes even more critical if biotechnology firms are to be assured of significant value appropriation in early-stage alliances.

Similarly, Figure 5 highlights one consequence of the intriguing finding that even as the overall number of alliances has grown dramatically, the number of late-stage projects has remained relatively constant, leading to a progressive decrease in the percentage of late-stage projects. Thus as the figure shows, as the percentage of late-stage projects has been falling over time, the average percentage of PS control rights won by pharmaceutical firms in late-stage alliances has been falling as well. Again therefore, superior complementarity becomes critical for any pharmaceutical firm wishing to buck the trend.

Figure 4

Early-Stage Biotechnology PS Control Rights vs. Number of Projects

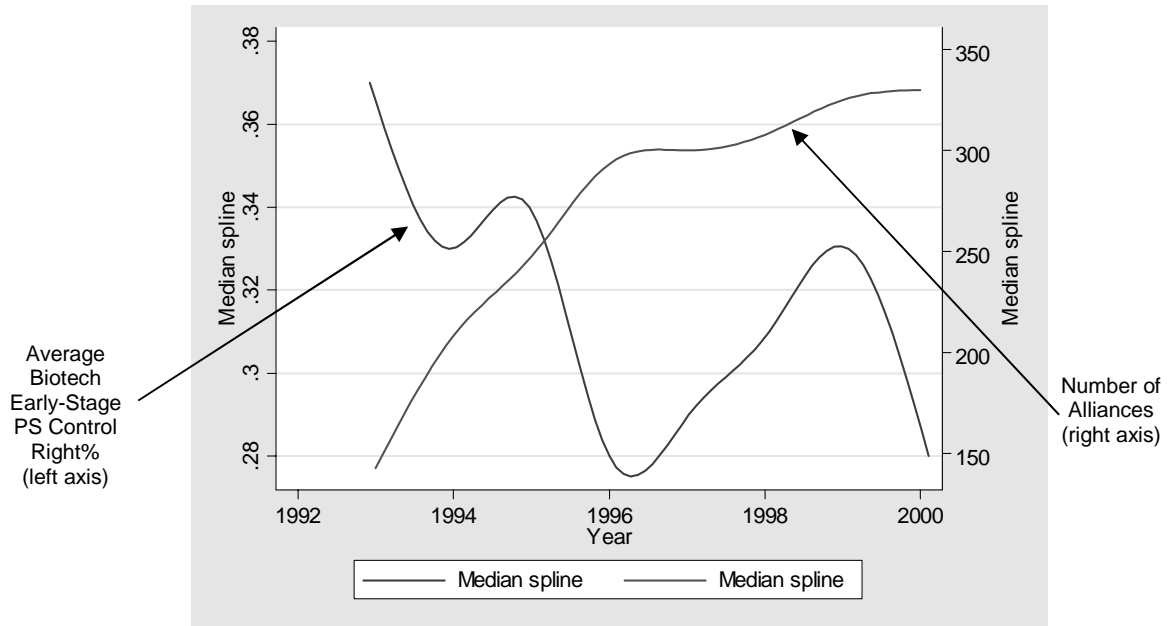
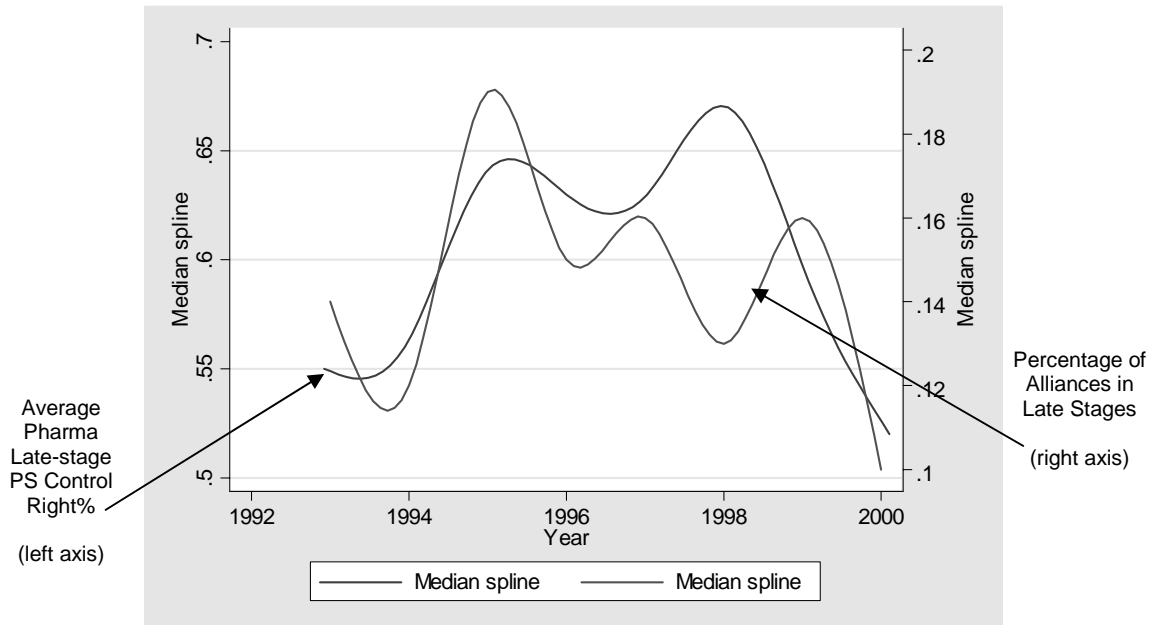


Figure 5

Late-Stage Pharmaceutical PS Control Rights vs. Percentage Late-Stage Alliances



However, we found limited or contradictory effects for the variables measuring relative bargaining ability. This could be because the effects of scarcity and superior complementarity “overpower” those of relative bargaining ability in this setting (i.e. for biotechnology R&D alliances $\partial_1 = \partial_0$ in Figure 1), or because our variables do not truly capture relative bargaining ability. We suggest that the former might be the case since the marginal biotechnology (or pharmaceutical) firm entering an R&D alliance probably varies little in complementarity relative to the best unpaired biotechnology (or pharmaceutical) firm. Thus in this setting most of the pie may be assigned by scarcity and superior complementarity, with little room for residual intra-pair bargaining.

Overall therefore, we feel confident about proposing that the amount of value an individual firm appropriates from an alliance (in the face of competition for alliance partners) depends on how scarce it and other firms of its type are; how much more valuable it is than other firms of its type; and how good it is at deal-making, relative to its alliance partner.

As such, we believe that our study makes several important contributions. Firstly, we address the critical issue of the impact of strategic alliances on firm performance by investigating intra-alliance differentials in value appropriation. This is important because unless studies of alliance outcomes are complemented by studies of the distribution of returns to collaboration, we will be unable to tell if or when better overall alliance outcomes improve the fortunes of specific partners in a collaborative relationship.

Secondly, this paper proposes a method for theoretically predicting and empirically measuring value appropriation, with a number of advantages. To start with, since important control rights are usually specified in filed alliance contracts, our proxy for value appropriation is readily accessible to most researchers. In addition, our measure captures a direct outcome of the alliance bargaining process, as opposed to a *reaction* (e.g. stock price appreciation or depreciation) to that outcome. We are also able to simultaneously capture the relative performance of both partners. Furthermore, our theoretical approach can be applied to a wide variety of situations amenable to representation in terms of coalitional bargaining in a strategic factor market.

Thirdly, our study highlights the fact that individual alliances often take place in the context of a wider market for alliance partners. Thus in the face of double-sided competition for potential partners, value appropriation is not necessarily symmetrical (as sometimes implicitly assumed) and strategic alliances will differentially benefit individual firms and groups of firms. Prevailing conditions of supply and demand interact with firm-specific resource and capability endowments to determine how much each firm benefits from collaboration.

Nonetheless, it is important to stress that we do not seek to de-emphasize the importance or the benefits of collaboration. Rather, we seek to emphasize the importance of “co-opetition” (Brandenburger and Nalebuff, 1996). Heightened consciousness of the fact that alliance partners have alternatives will lead firms to critically evaluate what and how much relative value they bring to the negotiating table; and this should help them improve their choice of strategic alliance partners. Firms are best advised (with respect to value appropriation) to enter those alliances where they exhibit superior complementarity relative to other firms. Although learning alliances may contribute more to future value creation, they are likely to be less favorable in terms of present value appropriation. As such, the tradeoff between value creation and value appropriation seems to exhibit the exploration vs. exploitation dilemma (March,

1991). Awareness of this tradeoff however, will enable firms to make the choices best in keeping with their strategies.

A fourth contribution of this paper is that it links the growing literature on alliance contractual design with the literature on alliance performance, opening the way for further future cross-fertilization. At the same time, however, we stress that it is important to recognize causal heterogeneity in the allocation of different alliance control rights and other contractual clauses. As such, researchers need to focus on the “correct” subset of contractual terms, depending on the causal mechanisms being studied.

Finally, our study contributes by providing an empirical application of a theory developed through formal modeling. In doing so, it highlights the great promise that the “bargaining perspective on resource advantage” (Lippman and Rumelt, 2003) holds for analyzing specific strategic issues in the resource-based view. One other indication of this is the fact that the present paper is one of very few empirical studies of strategic factor market theory.

Nevertheless, like all papers, ours too suffers from limitations. Firstly, the absence of other measures of intra-alliance value appropriation prevented us from carrying out an extensive validation of our new measure. Furthermore, the applicability of our measure is limited where alliance partners don’t explicitly allocate control rights, in addition to the fact that some measures of value appropriation (e.g. learning) are not easily “allocated” between partners. Nonetheless, we should point out that control rights have been used extensively in previous empirical research, and our only innovation has been to focus on those rights which we believe are related to value appropriation, as opposed to other mechanisms such as protection against potential opportunistic behavior, for example.

Theoretically too, our treatment of the alliance market implicitly assumes that all late-stage projects and all early-stage pharmaceutical dollars are identical. This was a necessary simplification, in order to bring the power of the coalitional approach to bear on our object of study. Finally, we are currently carrying out follow-up work with an increased late-stage sample size, in order to improve the statistical power of predictions in that sub-market.

Nevertheless, we believe that this study indicates a direction for further work on intra-alliance performance differentials. From an empirical standpoint, future studies could profitably explore the explanatory power of PS control rights in other industry contexts. Alternatively, researchers could carry out further contractual analyses to identify other measures of performance that may be embedded in formal (or even informal) alliance agreements. Other contractual clauses could also be used for testing predictions from property rights theory, transaction cost economics, the resource-based view, the relational view, etc.

From a theoretical standpoint, we believe that the concept of superior complementarity is ripe for further analysis. Given its critical impact in sourcing from strategic factor markets, further work could explore its antecedents, accumulation/acquisition, and its maintenance. Drawing on research on dynamic capabilities, researchers studying alliance performance could explore if and how firms are able to configure their complementarity to external resources in order to maximize their gains from collaboration. Finally, our theoretical approach, along with other variants of the “bargaining perspective” could be fruitfully applied to the study of value appropriation in such diverse settings as supplier relationships, technology sourcing, markets for star employees, and even intra-firm value appropriation dynamics.

Conclusion

The performance impact of individual alliances is an under-researched area in strategic management, and within this area, almost no previous work has attempted to theoretically and empirically tease apart the differential benefits reaped by individual alliance partners. In this paper we have tried to contribute to this area of investigation by proposing a measure of value appropriation and a theoretical approach amenable to the analysis and testing of the relative amount of value individual partners appropriate from strategic alliances. While our findings are very suggestive, they are not conclusive, and we seek to stimulate further theoretical refinement and empirical investigation in this critical area of research.

References

- Adegbesan J.T. 2005, "Strategic Factor Markets: Bargaining, Scarcity, and Resource Complementarity," Working Paper, IESE Business School, University of Navarra, Barcelona.
- Aghion P. and Tirole J. 1994, "The Management of Innovation," *Quarterly Journal of Economics* 109: 1185-1209
- Ahuja G. 2000, "Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study," *Administrative Science Quarterly* 45: 425-455
- Ahuja G., Coff R.W. and Lee P.M. 2005, "Managerial Foresight and Attempted Rent Appropriation: Insider Trading on Knowledge of Imminent Breakthroughs," *Strategic Management Journal* 26: 791-808
- Anand B. and Khanna T. 1997, "On the Market Valuation of Interfirm Agreements: Evidence from Computers and Telecommunications, 1990-1993," Working Paper, Harvard Business School.
- Argyres N.S. and Mayer K.J. 2004, "Contract Design Capability and Contract Performance by High Technology Firms: Implications for the Roles of Managers, Engineers, and Lawyers," Working Paper, Boston University School of Management, MA.
- Ariño A. and Reuer J.J. 2005, "Alliance Contractual Design," In O. Shenkar and J.J. Reuer (Eds.), *Handbook of Strategic Alliances*: 149-167. Sage
- Ariño A., Reuer J.J., Mayer K.J. and Jané J. 2005, "Contracting Costs in Outsourcing Partnerships: An Investigation of Termination Provisions," Unpublished Working Paper.
- Balakrishnan S. and Koza M.P. 1993, "Information Asymmetry, Adverse Selection and Joint Ventures: Theory and Evidence," *Journal of Economic Behavior and Organization* 20: 99-117
- Barney J.B. 1986, "Strategic Factor Markets: Expectations, Luck, and Business Strategy," *Management Science* 32(10): 1231-1241
- Barney J.B. 1988, "Returns to Bidding Firms in Mergers and Acquisitions: Reconsidering the Relatedness Hypothesis," *Strategic Management Journal* 9: 71-78
- Blau G.E., Pekny J.F., Varma V.A. and Bunch P.R. 2004, "Managing a Portfolio of Interdependent New Product Candidates in the Pharmaceutical Industry," *Journal of Product Innovation Management* 21: 227-245
- Brandenburger A.M. and Nalebuff B.J. 1996, *Co-opetition*, Currency-Doubleday: New York
- Cohen W.M. and Levinthal D.A. 1989, "Innovation and Learning: The Two Faces of R&D," *Economic Journal* 99: 569-596
- Conner K.R. 1991, "A Historical Comparison of Resource-based Theory and Five Schools of Thought within Industrial Organization Economics: Do We Have a New Theory of the Firm?" *Journal of Management* 17(1): 121-154

- Denrell J., Fang C. and Winter S.G. 2003, "The Economics of Strategic Opportunity," *Strategic Management Journal* 24: 977-990
- Dessein W. 2005, "Information and Control in Ventures and Alliances," *Journal of Finance* 60(5): 2513-2549
- Elfenbein D.W. and Lerner J. 2003, "Ownership and Control Rights in Internet Portal Alliances, 1995-1999," *Rand Journal of Economics* 34: 356-369
- George G., Zahra S.A., Wheatley K.K. and Khan R. 2001, "The Effects of Alliance Portfolio Characteristics and Absorptive Capacity on Performance: A Study of Biotechnology Firms," *Journal of High Technology Management Research* 12: 205-226
- Grossman S.J. and Hart O.D. 1986, "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy* 94(4): 691-719
- Gulati R. 1995, "Does Familiarity Breed Trust? The Implications of Repeated Ties for Contractual Choice in Alliances," *Academy of Management Journal* 38: 85-112
- Gulati R. 1998, "Alliances and Networks," *Strategic Management Journal* 19: 293-317
- Hagedoorn J. and Schakenraad J. 1994, "The Effect of Strategic Technology Alliances on Company Performance," *Strategic Management Journal* 15(4): 291-309
- Hart O. and Moore J. 1990. "Property Rights and the Nature of the Firm," *Journal of Political Economy* 98(6): 1119-1158
- Helfat C.E. 1997, "Know-how and Asset Complementarity and Dynamic Capability Accumulation: The Case of R&D," *Strategic Management Journal* 18(5): 339-360
- Henderson R.M. and Cockburn I.M. 1994, "Measuring Competence? Exploring Firm Effects in Pharmaceutical Research," *Strategic Management Journal* 15: 63-84
- Henderson R.M. and Cockburn I.M. 1996, "Scale, Scope and Spillovers: The Determinants of Research Productivity in Ethical Drug Discovery," *RAND Journal of Economics* 27: 32-59
- Hennart J.F. 1988, "A Transaction Cost Theory of Equity Joint Ventures," *Strategic Management Journal* 9: 361-374
- Higgins M.J. 2005, "The Allocation of Control Rights in Pharmaceutical Alliances," Working Paper, College of Management, Georgia Institute of Technology.
- Higgins M.J. and Rodriguez D. 2005, "The Outsourcing of R&D through Acquisitions in the Pharmaceutical Industry," *Journal of Financial Economics* forthcoming
- Hill C.W.L. and Rothaermel F.T. 2003, "The Performance of Incumbent Firms in the Face of Radical Technological Innovation," *Academy of Management Review* 28(2): 257-274
- Hoang H. and Rothaermel F.T. 2005, "The Effect of General and Partner-Specific Alliance Experience on Joint R&D Project Performance," *Academy of Management Journal* 48(2): 332-345
- Kleinbaum D.G., Kupper L.L. and Muller K.E. 1988, *Applied Regression Analysis and Other Multivariate Methods* (2nd ed.). PWS-Kent: Boston

- Koh J. and Venkatraman N. 1991, "Joint Venture Formations and Stock Market Reactions: An Assessment in the Information Technology Sector," *Academy of Management Journal* 34(4): 869-892
- Krieger N. and Ruback R.S. 2001, "Merck and Company: Evaluating a Drug Licensing Opportunity," Case 9-201-023, Harvard Business School, Cambridge, MA.
- Leland H. and Pyle D. 1977, "Information Asymmetries, Financial Structures, and Financial Intermediation," *Journal of Finance* 32: 371-388
- Lerner J. and Merces R.P. 1998, "The Control of Technology Alliances: An Empirical Analysis of the Biotechnology Industry," *Journal of Industrial Economics* 46(2): 125-156
- Lerner J., Shane H. and Tsai A. 2003, "Do Equity Financing Cycles Matter? Evidence from Biotechnology Alliances," *Journal of Financial Economics* 67: 411-446
- Lippman S.A. and Rumelt R.P. 2003, "A Bargaining Perspective on Resource Advantage," *Strategic Management Journal* 24: 1069-1086
- Luo Y. 2002, "Contract, Cooperation, and Performance in International Joint Ventures," *Strategic Management Journal* 23: 903-920
- Madhok A. and Tallman S.B. 1998, "Resources, Transactions, and Rents: Managing Value Through Inter-Firm Collaborative Relationships," *Organization Science* 9: 326-339
- Makadok R. and Barney J.B. 2001, "Strategic Factor Market Intelligence: An Application of Information Economics to Strategy Formulation and Competitor Intelligence," *Management Science* 47(12): 1621-1638
- March J.G. 1991. "Exploration and Exploitation in Organizational Learning," *Organization Science* 2(1): 71-87
- Mayer K.J. and Argyres N.S. 2004, "Learning to Contract: Evidence from the Personal Computer Industry," *Organization Science* 15(4): 394-410
- Mowery D.C., Oxley J.E. and Silverman B.S. 1996, "Strategic Alliances and Interfirm Knowledge Transfer," *Strategic Management Journal* 17(Winter Special Issue): 77-91
- Nerkar A. and Roberts P.W. 2004, "Technological and Product-Market Experience and the Success of New Product Introductions in the Pharmaceutical Industry," *Strategic Management Journal* 25: 779-799
- Oxley J.E. 1997, "Appropriability Hazards and Governance in Strategic Alliances: A Transaction Cost Approach," *Journal of Law, Economics, and Organization* 13: 387-409
- Papke L.E. and Wooldridge J.M. 1996, "Econometric Methods for Fractional Response Variables with an Application to 401(k) Plan Participation Rates," *Journal of Applied Econometrics* 11: 619-632
- Pisano G.P. 1989, "Using Equity Participation to Support Exchange: Evidence from the Biotechnology Industry," *Journal of Law, Economics, and Organization* 5: 109-126
- Pisano G.P. 1990, "The R&D Boundaries of the Firm: An Empirical Analysis," *Administrative Science Quarterly* 35: 153-176

- Poppo L. and Zenger T. 2002, "Do Formal Contracts and Relational Governance Function as Substitutes or Complements?" *Strategic Management Journal* 23(8): 707-725
- Powell W.W. and Brantley P. 1992, "Competitive Cooperation in Biotechnology: Learning Through Networks?" In N. Nohria and R.G. Eccles (Eds.), *Network and Organizations: Structure, Form and Action*: 366-394. Harvard Business School Press: Boston
- Recombinant Capital. 2006, Available at: <http://www.recap.com>: 6/6/06
- Reuer J.J. and Ariño A. 2003, "Strategic Alliances as Contractual Forms," *Academy of Management Best Paper Proceedings*
- Reuer J.J. and Ariño A. 2005, "Contractual Complexity in Strategic Alliances," Working Paper, Kenan-Flagler Business School and IESE Business School.
- Reuer J.J., Ariño A. and Mellewigt T. 2005, "Entrepreneurial Alliances as Contractual Forms," *Journal of Business Venturing* forthcoming
- Rothaermel F.T. 2001, "Incumbent's Advantage through Exploiting Complementary Assets via Interfirm Cooperation," *Strategic Management Journal* 22(6/7): 687-699
- Rothaermel F.T. and Deeds D.L. 2004, "Exploration and Exploitation Alliances in Biotechnology: A System of New Product Development," *Strategic Management Journal* 25: 201-221
- Ryall M.D. and Sampson R.C. 2003, "Do Prior Alliances Influence Contract Structure? Evidence from Technology Alliance Contracts," Working Paper No. FR 03-11, Simon School of Business (Available at: <http://ssrn.com/abstract=396601>).
- Sarkar M., Echambadi R. and Harrison J.S. 2001, "Alliance Entrepreneurship and Firm Market Performance," *Strategic Management Journal* 22: 701-711
- Stern I. and Dukerich J.M. 2006, "All that Glitters is not Gold: Scientists' Academic Status Attributes and Alliance Formation between Pharmaceutical and Biotechnology Firms," Working Paper, Northwestern University and University of Texas at Austin.
- Thomke S. and Kuemmerle W. 2002, "Asset Accumulation, Interdependence and Technological Change: Evidence from Pharmaceutical Drug Discovery," *Strategic Management Journal* 23: 619-635
- Zaheer A., McEvily B. and Perrone V. 1998, "Does Trust Matter? Exploring the Effects of Interorganizational and Interpersonal Trust on Performance," *Organization Science* 9: 123-141
- Zollo M., Reuer J.J. and Singh H. 2002, "Interorganizational Routines and Performance in Strategic Alliances," *Organization Science* 13(6): 701-713

Appendix 4.1

control rights

a. “Pie-Splitting” Control Rights

“Pie-Splitting” Control Rights are coded from the point of view of the pharmaceutical firm, following legal practice. While some are cumulative (e.g. basic/universal/marketing process rights or partial/exclusive patent ownership), others are binary (e.g. right to sublicense).

- Partial patent ownership:
- Exclusive patent ownership
- Right to transfer of unpatented “know-how”
- Ownership of unpatented “know-how”
- Right to sublicense
- Continued licensing rights on *expiration*
- Right to manufacture final product
- Basic marketing rights
- Universal marketing rights (all territories, diseases, and products)
- Control of entire marketing process (no co-promotion)

b. The 25 Control Rights from Lerner and Merges (1998)

- Aspects of Alliance Management
 1. Right to manage clinical trials
 2. Right to undertake process development
 3. Right to manufacture final product
 4. Right to market universally
 5. Right to market product alone
- Determination of Alliance Scope
 6. Right to expand alliance
 7. Right to extend alliance
 8. Right to terminate alliance without cause
 9. Right to terminate particular projects
 10. Right to sub-license
 11. Right to license after expiration/termination
 12. Right to “shelve” projects
- Control of Intellectual Property
 13. Ownership of patents
 14. At least partial patent ownership
 15. Control of patent litigation
 16. Right to know-how transfer
 17. Ownership of core technology
 18. Right to delay publications
 19. Right to suppress publications

Appendix 4.1 (continued)

- **Governance Structures**
 20. Control of top project management body
 21. Seat on R&D firm's board
 22. Equity in R&D firm
 23. Right to participate in R&D firm's financings
 24. Right to register R&D firm's stock
 25. Ability to make public equity purchases

c. The 10 Control Rights from Higgins (2005)

- **Intellectual Property Rights**
 1. Ownership of patents
 2. Control and responsibility for patent litigation process
 3. Transfer of unpatented R&D "know-how"
- **Licensing Rights**
 4. Right to sub-license
 5. Royalty payment tie-ins
- **Clinical Trial and Distribution Rights**
 6. Management of clinical trials
 7. Control of initial manufacturing process
 8. Marketing rights to the product
- **Exit Rights**
 9. Product reversion rights upon termination
 10. Right to terminate without cause