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THE INTRA-ALLIANCE DIVISION OF VALUE CREATED THROUGH COLLABORATION

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The differential benefits reaped by individual partners are a major determinant of the impact of strategic alliances on firm performance and an important (dis)incentive for alliance partners to collaborate in value creation. Theoretically, we lack an explicit theory of intra-alliance value division; empirically, previous analysis has been hampered by methodological challenges. We propose a bargaining framework for intra-alliance value appropriation, as well as a measure for capturing its variation. We test our hypotheses on a sample of 200 biotechnology R&D alliances, and are able to explain variation in value appropriation across alliance partners, partner types, and individual firms of each type. Copyright © 2010 John Wiley & Sons, Ltd.

INTRODUCTION

What determines how the value created by an alliance is divided among its members? Studies of strategic alliances identify a mixture of cooperation and competition as key factors in interfirm collaboration (Khanna, Gulati, and Nohria, 1998; Oxley and Silverman, 2008). It is somewhat surprising then, that while many studies have investigated the creation of value by strategic alliances, very few have explored the determinants of its division between partners.

Theoretical consideration of value *creation* in strategic alliances has built upon Dyer and Singh's (1998) seminal concept of 'relational rents.' Dyer and Singh argued that alliances that involve relation-specific assets, knowledge-sharing routines, complementary resources/capabilities, and effective governance, can 'be a source of relational rents and competitive advantage' (1998: 661). However, for relational rents to impact performance, they have to be *appropriated* by specific firms. Thus, a natural question not answered by their path-breaking framework is: How do relational rents get shared between alliance partners?

Relatedly, firm-level research in the resource-based view (Peteraf and Barney, 2003) has shown that rent generation may not lead to superior performance because rents may be appropriated by different stakeholders within the firm (Coff, 1999). However, this issue is yet to be adequately addressed at the alliance level. We do not know enough about if, when, and why alliance partners may benefit equally or asymmetrically from relational rents; this question is both relevant and urgent (Oxley and Silverman, 2008). While we have an explicit theory of the creation of value in alliances (Dyer and Singh, 1998), we do not have an explicit mechanism describing its distribution.

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Furthermore, as Parkhe argued some years ago, 'the performance of a strategic alliance will be significantly related to the pattern of payoffs characterizing it' (1993: 799). Value creation in interfirm collaboration is not independent of anticipated value appropriation since this latter criterion determines an alliance partner's effort and incentive to contribute. Consequently, it is important to elucidate the interactions between the drivers of value creation and the drivers of value appropriation, which is difficult to do in the absence of an explicit theory of value appropriation. It is not surprising, therefore, that Dyer and Singh already pointed out that an 'important avenue for future research would be to examine how relational rents are distributed among alliance partners' (1998: 676).

As a small step in this important direction, we propose a theoretical approach and a new method of measuring value appropriation, whereby we predict and test the determinants of the portion of value created by an alliance that each partner appropriates.

Our theoretical approach derives from work by Adegbesan (2009), who uses the recent 'bargaining perspective on resource advantage' (Lippman and Rumelt, 2003) to extend strategic factor market theory (Barney, 1986) to account for situations where acquiring firms display heterogeneous complementarity to target resources. He shows that in such situations, the amount of value each firm stands to appropriate 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.

We apply this theory to intra-alliance value division in the empirical setting of biotechnology research and development (R&D) alliances. We conceptualize biotechnology R&D alliances as taking place in strategic factor markets where biotechnology firms provide specialized knowledge and research skills, while pharmaceutical firms contribute funding and product development, approval process, and marketing capabilities. In these double-sided markets, there is a simultaneous demand for and supply of *both* pharmaceutical and biotechnology firms, and the consequent competition determines the 'splitting of the pie' within the alliances that eventually form.

We proxy value appropriation with the share of a key subset of alliance control rights won by each partner. Previous research has tended to look at alliance control rights as a homogeneous set responding only to concerns of output maximization and opportunistic behavior. We argue, however, that control rights are not homogeneous but fulfill different alliance functions, therefore, lumping all of them together leads to ambiguous results. In this paper, we focus on the percentage of a subset of 'pie-splitting' (PS) control rights won by each partner. PS control rights confer ownership and control over activities and intermediate outputs that directly affect the allocation of portions of the overall value to be created by an alliance. Thus, bargaining over pie-splitting control rights helps alliance partners work around the uncertainty involved in splitting future value in the present.

Our results support the view that the amount of value an individual firm stands to appropriate from an alliance 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 great its bargaining ability is, relative to its alliance partner. Thus, our study underlines the fact that individual alliances often take place within the context of a wider market for alliance partners. Prevailing conditions of supply and demand interact with firm-specific resource and capability endowments to determine value appropriation. In addition, each individual firm's alternative value-creating options affect bargaining positions, thus determining how much each firm benefits from collaboration.

The rest of the paper is organized as follows. First we review relevant literature, followed by an exposition of our theoretical approach. We then use our theory to generate a series of hypotheses, the tests and results of which are then detailed. Finally, we end by discussing implications, limitations, and possible extensions of our findings.

THEORY AND HYPOTHESES

A strategic alliance is a voluntary arrangement between independent firms to exchange or share resources and engage in the codevelopment or provision of products, services, or technologies (Gulati, 1998). Although value appropriation is an important driver of the impact of strategic alliances on firm performance, it is an issue that has been underexplored, not only in alliance research, but in strategic management research as a whole (Barney, 2001; Coff, 1999; Oxley and Silverman, 2008).

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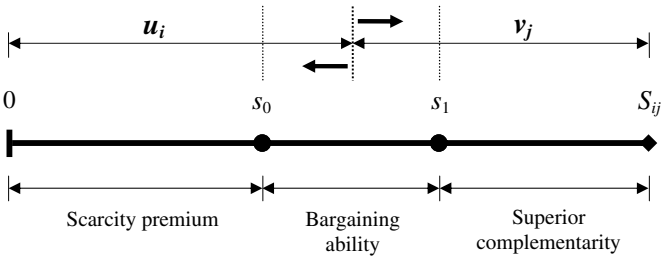

Figure 1. Components of surplus split

Previous work on the impact of strategic alliances on the performance of partner firms has taken two major approaches. First, event study analyses of stock market reactions to alliance announcements have been used to proxy the likely future impact of alliances on firm performance (e.g., Anand and Khanna, 2000; Balakrishnan and Koza, 1993; Koh and Venkatraman, 1991). Second, researchers have analyzed 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). Nevertheless, while these approaches have advanced knowledge tremendously, they have also provided mixed evidence (Gulati, 1998), and their measures have often focused on only one partner or have had difficulties disentangling alliance performance effects from those due to other firm activities. *Ceteris paribus*, the greater the portion of value created by a strategic alliance that an individual partner is able to appropriate, the better its performance will be. Consequently, the analysis of intra-alliance value division can help to shed further light on this important issue.

Bargaining over value in strategic alliances

In an influential paper, Lippman and Rumelt (2003) suggest that we can make progress in the analysis of value appropriation by conceptualizing it as the outcome of coalitional bargaining over 'surpluses' resulting from the combination of complementary resources. When there is some degree of complementarity 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 their combination results in the creation of a surplus S such that $v(R_1 \cup R_2) = v(R_1) + v(R_2) + S$, where $S > 0$ (Adegbesan, 2009; Dyer and Singh, 1998). The magnitude of the surplus created is proportional to the degree of complementarity between the resources, and because it does not 'belong' to either resource but results from their *combination*, the way it is split between them is indeterminate *ex ante*. Thus, if the firm that owns R_2 is able to appropriate a positive share of the surplus S, it can realize gains to trade even if it had to pay $v(R_1)$ for the services of R_1. Consequently, in Lippman and Rumelt's (2003) 'bargaining perspective,' the critical variables in the analysis of value appropriation are the drivers of the outcome of the bargaining process by means of which players split a surplus among themselves.

Adegbesan (2009) applies Lippman and Rumelt's (2003) approach to strategic factor market (SFM) theory (Barney, 1986; Makadok and Barney, 2001) by focusing on factor markets characterized by acquiring firms that display heterogeneous complementarity to target resources. He formally shows that when firms acquire resources in this type of SFM,[1] the split of surplus with resource suppliers will depend 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 (see Figure 1, from Adegbesan [2009]). In other words, a given acquiring firm will appropriate a greater portion of surplus, (i) the lesser the scarcity of sellers relative to buyers, (ii) the greater the amount of surplus it can create with the target resource relative to other buyers (superior complementarity), or (iii) the greater its bargaining ability relative to its partner.

[1] A 'strategic factor market' is 'a market where the resources necessary to implement a strategy are acquired' (Barney, 1986: 1231).

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Adegbesan's (2009) SFM results are thus driven by scarcity, heterogeneous complementarity, and bargaining ability. Firstly, when members of a group (buyers or sellers) are scarce, some member(s) of the other group will be left unpaired. Consequently, the presence of such willing but unpaired players places a nonzero lower bound on the appropriation level of members of the scarce group (s_0 in Figure 1), and this minimum appropriation level tends to increase with the degree of relative scarcity.[2] Thus the relative scarcity of player types is one driver of how much individual firms will appropriate.

Secondly, competition among members of one group to pair with more valuable members of the other group causes the latter to capture more surplus in proportion to their degree of superior complementarity. The greater a player's complementarity relative to the least valuable *paired* member of its own group ($S_{ij} - s_1$ in Figure 1), the greater the share of surplus it will appropriate (Adegbesan, 2009).[3] Consequently, superior complementarity is another driver of how much individual firms will appropriate.

Thirdly, bargaining ability combines with the exercise of strategic alternatives to determine value appropriation. A portion of the surplus ($s_1 - s_0$ in Figure 1) is split within each pair according to the relative bargaining positions of each player (Adegbesan, 2009; MacDonald and Ryall, 2004). As such, relative bargaining ability is a final driver of how much each firm appropriates.

In summary, in this 'bargaining perspective' on SFM, the intra-pair split of value is driven by intergroup, intragroup, and intra-pair competition over surplus, acting through relative scarcity, superior complementarity, and bargaining ability, respectively (Adegbesan, 2009).

Nevertheless, Lippman and Rumelt (2003) were not the first to reflect on the impact of (bargaining) power on interorganizational relations.[4] In particular, resource dependence theory (Pfeffer and Salancik, 1978) has long studied the role of power and dependence in relationships between organizations. The theory's central thesis is that organizational *survival* depends on the ability to procure critical resources from the external environment, and, thus, organizations will act to reduce uncertainty in the flow of needed resources (Casciaro and Piskorski, 2005; Pfeffer and Salancik, 1978). Uncertainty or constraints in the supply of such critical resources create a dependence on resource providers, who thus acquire power over the dependent organization (Emerson, 1962; Provan, Beyer, and Kruytbosch, 1980). The degree of dependence is a function of the criticality of the resources in question and their availability from alternative suppliers (Emerson, 1962). However, since a resource provider is also dependent on a constrained organization to some extent, at the dyadic level, resource dependence has two dimensions: power imbalance and mutual dependence (Casciaro and Piskorski, 2005; Emerson, 1962). These two dimensions influence (i) the likelihood of *power use operations* by the dominant organization; and (ii) the likelihood of three types of *operations to restructure dependencies* by the weaker organization: unilateral tactics, cooptation, or constraint absorption (Casciaro and Piskorski, 2005; Pfeffer, 1972; Pfeffer and Leong, 1977).

One difficulty with applying resource dependence theory to our subject of study is that intra-alliance value division displays aspects of *both* power use and constraint absorption operations.[5] In resource dependence theory, while the likelihood of power use is positively related to the degree of power imbalance and preserves the power-dependence structure (Casciaro and Piskorski, 2005); the likelihood of constraint absorption is *negatively related* to power imbalance, positively related to mutual dependence, and *eliminates or restructures* the power-dependence relationship (Casciaro and Piskorski, 2005). Thus using extant resource dependence theory, it would

[2] The lower bound on appropriation for scarce players is the amount of surplus that could be created with the *best unpaired* member of the group with too many players (Adegbesan, 2009). Clearly, if a scarce player were to be offered an amount less than this, it could simply leave the game to pair up with that player on its own.

[3] Superior complementarity is measured relative to the least valuable *paired* member of a group because that firm's partner would be willing to pay the most to get a more valuable firm to pair with (Adegbesan, 2009). If a member of the group were to receive less than this premium, it could maximize its returns by offering a better value-creating deal to the partner of the least valuable firm.

[4] In fact, the coalitional approach they suggest was first introduced to strategic management by Brandenburger and Stuart (1996).

[5] In resource dependence theory, mergers and acquisitions, joint ventures, and alliances are typically seen as constraint absorption operations *by the weaker organization*, which reduce dependence to the degree that they absorb the constraining partner, thus restructuring the power-dependence relationship.

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not be easy to predict how the two dimensions of resource dependence play out in intra-alliance value division.

In addition, resource dependence theory's focus on resource scarcity and *criticality* reflects its theoretical concern with issues such as constraints, dependence, and organizational survival. However, our focus on scarcity and *complementarity* reflects an interest in issues such as innovation, surplus, and competitive advantage. Consequently it would not be a trivial task to relate bargaining behavior across these two contexts. Finally, the coalitional approach suggested by Lippman and Rumelt (2003) has the advantage of going beyond the dyadic level to simultaneously capture competition at intragroup and intergroup levels.

In summary therefore, although a thorough analysis of the differences and overlaps between the two approaches goes beyond the scope of this paper, we believe that Adegbesan's (2009) SFM application of Lippman and Rumelt's (2003) approach has a better theoretical fit with the issues at hand. As such, we suggest that if we conceptualize strategic alliances as taking place in SFM characterized by competition and heterogeneous complementarity, 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.

Pie-splitting control rights and value appropriation

In a parallel development, research on alliance design is focusing increasingly on the contractual provisions firms use to structure their relationships (e.g., Ariño and Reuer, 2005; Mayer and Argyres, 2004; Poppo and Zenger, 2002; Ryall and Sampson, 2006). This stream of work suggests that the analysis of contractual provisions can provide a bridge between research on alliance design and research on the performance of alliance partners, since contracts also specify the distribution of gains between alliance partners (Elfenbein and Lerner, 2003). Already, some authors have underlined the impact of contractual complexity on contracting costs and alliance performance (e.g., Ariño and Reuer, 2005; Poppo and Zenger, 2002; Reuer and Ariño, 2007). However, a critical area yet to be explored is how contractual provisions reflect the distribution of returns to collaborative activity.

One important set of contractual provisions relates to alliance control rights. Alliances that develop new products, services, or technologies tend to be complex and unpredictable, making it difficult to specify all the features of products to be developed *ex ante* (Henderson and Cockburn, 1994; Pisano, 1990). Given the associated uncertainties, partner firms often cannot directly bargain over the distribution of future income streams, but must rather bargain over *the ownership and control of activities, decisions, and intermediate outputs related to the creation and distribution of those possible streams*. The allocation of these 'control rights' thus has a critical impact on the amount of value created in a strategic alliance, as well as on its distribution between partners, and for this reason, 'the allocation of control rights is a central issue in the negotiation of alliances' (Lerner and Merges, 1998: 127). It is therefore no surprise that control rights have been studied in settings as diverse as biotechnology (Lerner and Merges, 1998); Internet portals (Elfenbein and Lerner, 2003); government contracts (Ciccotello and Hornyak, 2000); fine chemicals (Hagedoorn and Hesen, 2007); information service exchanges (Poppo and Zenger, 2002); and venture capital (Hellmann, 2003).

Nevertheless, most previous empirical work has failed to account for functionally differentiated subsets among control rights, leading to mixed results. Elfenbein and Lerner (2003) for instance, found that while the 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. Thus, 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 identifying and focusing specifically on the PS control rights, which reflect the *ex ante* allocation of value between partners.

PS control rights are those that confer ownership and control over activities and intermediate outputs that directly affect the allocation of portions of the overall value to be created by an alliance. Thus although control rights have many functions (such as splitting an uncertain future pie, distribution of tasks and responsibilities, planning for foreseeable contingencies, efficient alignment of *ex post* behavior, signaling of congruence, and so

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forth (cf. Ariño and Reuer, 2005; Dessein, 2005; Oxley, 1997), we hold that PS control rights are those most closely related to intra-alliance value division.

PS control rights thus 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 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, 2007).

We suggest that the more of an alliance's PS control rights won by a partner, the better that individual firm's performance will be, other things being equal. In turn, using Adegbesan's (2009) bargaining framework, we suggest that the greater a firm's relative scarcity, superior complementarity, or relative bargaining ability the greater the share of alliance PS control rights it will win. We now go on to develop a series of hypotheses, by applying our theory and measure to value appropriation in biotechnology R&D alliances.

Analyzing value appropriation in biotechnology R&D alliances

The bargaining positions of partners in a biotechnology alliance depend on the stage of development of the lead product candidate when the alliance is signed (Higgins, 2007; Lerner and Merges, 1998), as well as on a series of factors that determine scarcity, complementarity, and bargaining ability at each stage. On the one hand, the market for early-stage alliances is typically characterized by many cash-strapped R&D firms jostling for limited pharmaceutical dollars in the presence of a substantial degree of asymmetric information (Lerner, Shane, and Tsai, 2003). On the other hand however, the market for late-stage alliances is typically characterized by fewer R&D firms courted by a relatively larger number of pharmaceutical firms, since the former's advanced projects now have a higher likelihood of success (Rothaermel, 2001). Consequently, we expect bargaining dynamics to differ significantly across stages, and we make this distinction in our theorizing. Our paper is thus one of very few to consider the bargaining positions of *both* pharmaceutical and biotechnology firms (Higgins, 2007), and the only one we know of that considers this across both early- and late-stage alliances.

Relative scarcity

Since the late 1970s, over 1,600 biotechnology firms (with multiple projects each) have appeared (Rothaermel, 2002), while, on the other hand, the number of pharmaceutical firms active in biotechnology has dropped from 43 to 30 (Hoang and Rothaermel, 2005). *For early-stage projects*, biotechnology firms have limited access to nonspecialized funding (Lerner *et al*., 2003), while pharmaceutical firms have limited resources to spend on external R&D (Pisano, 1990). As such, there is a scarcity of financing in comparison to the number of early-stage projects brought to the alliance market.

Since R&D firms vary in quality (Dessein, 2005), those perceived to be more valuable will be preferentially funded, and as a result some of the less prized ones will not receive funding (Powell and Brantley, 1992; Stern and Dukerich, 2006). The lower the pharmaceutical funding available in a given period, the fewer the R&D firms that receive funding, and thus the more valuable the best unpaired (unfunded) R&D firm is, and the greater the share of PS control rights each pharmaceutical firm wins as a result (Adegbesan, 2009). Thus in early-stage alliances, pharmaceutical firms comprise the scarcer group, and the degree of relative scarcity is driven by the availability of pharmaceutical funding. 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.*[6]

The roles are significantly reversed in markets for *late-stage alliances*. Given that the further advanced a research project is, the higher its likelihood of success; late-stage projects are very attractive to pharmaceutical firms (Higgins, 2007; Rothaermel, 2001). Nevertheless, only 0.05 percent of early-stage R&D projects eventually

[6] 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.

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become late-stage projects (Rothaermel and Deeds, 2004). Consequently there is a scarcity of late-stage projects in comparison to the pharmaceutical firms willing to take them on.

The few biotechnology firms that bring late-stage projects to the alliance market can therefore 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). The fewer the late-stage projects brought to the alliance market, the fewer the pharmaceutical firms that are able to enter into late-stage alliances, and thus the more valuable the best unpaired pharmaceutical firm is and the greater the share of PS control rights each biotechnology firm wins (Adegbesan, 2009). As such, in late-stage alliances, biotechnology firms comprise the scarcer group, and the availability of late-stage projects drives relative scarcity. So we hypothesize:

Hypothesis 2a: 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.

Relative scarcity in late-stage alliances may also be driven by the availability of alternative funding for biotechnology firms. As R&D projects advance into later stages, initial information problems are alleviated and biotechnology firms are better able to attract public investors, who require less of a premium than specialized investors (Lerner *et al*., 2003). In addition, since biotechnology firms have an informational advantage over pharmaceutical firms regarding the quality of the projects they bring to the alliance market, pharmaceutical firms may discount late-stage projects, offering less attractive deals to guard against a 'lemons problem' (Akerlof, 1970; Rothaermel and Deeds, 2004). Consequently when public funding is more available, fewer biotechnology firms will bring late-stage projects to the alliance market (Lerner and Merges, 1998; Lerner *et al*., 2003), thus increasing relative scarcity. As such, we hypothesize:

Hypothesis 2b: For late-stage alliances, the greater the availability of public funding for biotechnology projects in a period, the higher the percentage of PS control rights won by each biotechnology firm.

Superior complementarity

In addition to scarcity effects, firms also compete to ally with more valuable players of the other type. In *early-stage alliances*, a biotechnology firm's superior complementarity refers to how much more value it is likely to create with pharmaceutical dollars compared with the least valuable paired R&D firm. The variance in quality among R&D firms leads to competition among pharmaceutical firms to ally with biotechnology firms perceived to be more valuable (Stern and Dukerich, 2006), causing these latter to appropriate more (Adegbesan, 2009).

One important way pharmaceutical firms appraise the prospects of biotechnology firms is by evaluating their patent portfolios. Rothaermel (2002: 395) found that biotechnology firms with more patents were 'consistently more attractive as alliance partners for incumbent pharmaceutical companies.' An R&D firm's patent portfolio is considered to be an independent observable indicator of its research capabilities and intellectual property pool (George *et al*., 2001; Henderson and Cockburn, 1994). Therefore the larger an R&D firm's patent portfolio relative to those of other paired firms, the more valuable it is perceived to be, the more sought after it is, and the more PS control rights it will retain. So we hypothesize:

Hypothesis 3a: For early-stage alliances, the larger a biotechnology firm's patent portfolio at signing relative to the paired biotechnology firm with the fewest patents, the higher the percentage of PS control rights it retains.

Another factor that pharmaceutical firms value highly 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 very high, partly due to the fact that many biotechnology firms are start-ups based on the innovative ideas of one or more university researchers (Stern and Dukerich, 2006), and many of these ideas do not eventually stand the test of large-scale laboratory development (Rothaermel and Deeds, 2004). Consequently, R&D firms that have validated their core technologies in previous projects typically stand a greater chance of discovering valuable new drugs than firms that have not. In addition, previous projects signal that other investors have found

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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). As such, R&D firms with more experience exhibit superior complementarity and will therefore retain more PS control rights. Consequently we hypothesize:

Hypothesis 3b: For early-stage alliances, the greater a biotechnology firm's previous experience with R&D projects relative to the paired biotechnology firm with the least experience, the higher the percentage of PS control rights it retains.

Moving to *late-stage alliances*, superior complementarity is important because many biotechnology firms lack experience with taking new drug projects from clinical trials and regulatory approval through manufacturing to marketing (Rothaermel, 2001). Therefore, despite scarcity effects in their favor, biotechnology firms will still compete to ally with pharmaceutical firms possessing superior research, clinical testing, and marketing capabilities (Helfat, 1997; Henderson and Cockburn, 1994). As such, in late-stage alliances, a pharmaceutical firm's superior complementarity refers to how much more value it is likely to add to a late-stage research project compared with the least valuable paired pharmaceutical firm.

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 complementary assets necessary for carrying out large-scale clinical trials, strong relationships with regulatory authorities, and extensive manufacturing, detailing, and distribution capabilities and infrastructure (Hoang and Rothaermel, 2005). Thus, pharmaceutical firms having greater experience with late-stage projects are more prized by biotechnology firms, and are consequently assured more PS control rights than other pharmaceutical firms with less experience. Hence we hypothesize:

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 is not the only contribution pharmaceutical firms can make to late-stage alliances. Late-stage projects continue to require intensive ongoing R&D in response to initial clinical results, indications from regulatory authorities, and continual technological advances in the research area (George *et al*., 2001; Lerner and Merges, 1998). Pharmaceutical firms with superior absorptive capacity are better able to recognize the value of new knowledge, assimilate it, and apply it to commercial ends (Cohen and Levinthal, 1990). They are thus better able to contribute to the biotechnology firm's knowledge base, as well as to play an effective role in problem solving (George *et al*., 2001; Helfat, 1997; Henderson and Cockburn, 1994). Thus, pharmaceutical firms with superior absorptive capacity display superior complementarity in late-stage research projects. Consequently we hypothesize:

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

Relative bargaining ability

Finally, bargaining ability also determines how much value each firm will appropriate. A portion of the surplus is split according to the relative *intra-pair* bargaining positions of alliance partners (Adegbesan, 2009). 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 PS control rights it wins.

A biotechnology firm's bargaining ability is influenced by how badly it needs external financing (Lerner and Merges, 1998). Most biotechnology firms have negative cash flows, and those that are more desperate for external funding have a weaker ability to bargain over PS control rights relative to their partner (Higgins, 2007; 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 influenced by the health of

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its product pipeline (Higgins, 2007; Higgins and Rodriguez, 2006). Pharmaceutical firms with static or deteriorating product pipelines are more desperate for promising R&D projects, and thus less able to extract value from their partner (Higgins, 2007). 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. As such, we hypothesize:

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

Finally, pharmaceutical firms are usually involved in several concurrent alliances that provide them with multiple options for developing profitable drugs (McGrath and Nerkar, 2004). Therefore, the larger a pharmaceutical firm's alliance portfolio, the less dependent it is on any one alliance, and consequently, the greater its bargaining ability relative to its biotechnology partner will be. As such, we hypothesize:

Hypothesis 5c: The larger a pharmaceutical firm's alliance portfolio, the higher the percentage of PS control rights it wins.

DATA AND METHODS

We obtained alliance information from Recombinant Capital (Recap), a California-based firm recently acquired by Deloitte. Recap's alliance database contains over 29,000 biotechnology alliances, including some 12,000 actual alliance contracts (Deloitte Recap LLC, 2009). A recent study found that Recap had the broadest relative coverage when compared with the other major biotechnology alliance databases, but that all four databases seemed to be 'representative samples of the true alliance activity over this time period'[7] (Schilling, 2009: 250).

In identifying R&D alliances, we focused on those alliances in which a license was involved. Unlike in joint marketing alliances or most manufacturing alliances, in biotechnology R&D alliances the creation, usage, ownership, and licensing of intellectual property is a central issue. As such, intellectual property licenses are virtually always involved. In addition, such alliances usually entail an explicit allocation of control rights, which is ideal for our purposes.

We randomly selected 200 alliances that took place between 1991 and 2000. By focusing on this time frame, we were able to track down financial information for biotechnology firms that were privately held at alliance inception, and so we did not have to limit our sample to publicly held biotechnology firms as in many previous studies. In addition, the time period also captures two separate biotechnology initial public offering (IPO) windows (1991–1993 and 1996–2000), as well as a dramatic increase in pharmaceutical-biotechnology alliances.

Based on our theory and consistent with prior work we eliminated alliances where:

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

We replaced each eliminated alliance with another random draw (Higgins, 2007; Lerner *et al.*, 2003).

For each alliance, we then extracted information that included: the date and length of the alliance, the technology and subject covered, total value, upfront payments, royalty rates, contingent or milestone payments, and R&D payments. In addition, we conducted an in-depth content analysis of each contract to identify the allocation of various control rights, the presence and magnitude of royalties, and the allocation of equity. We coded alliances pursuing molecule discovery, lead molecule development, or preclinical development as 'early-stage' alliances, while those in clinical testing or undergoing regulatory review were coded as 'late-stage' alliances.

Dependent variable

Following from our theoretical focus on the *share* of a valuable pool of rights won by each alliance

[7] 1990–2005.

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partner, our measure had to capture the amount won by each partner *relative to the size of the pool*. We therefore operationalized this requirement by focusing on the percentage of PS control rights won by the pharmaceutical firm.

To identify which control rights are PS in biotechnology R&D alliances, we combined an extensive review of the literature on R&D alliances and alliance contractual design with input from industry practitioners, including the head of alliance management at one of the top-10 global pharmaceutical firms. In this way, we identified the following 10 *PS* control rights:

- 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 counted the number of PS control rights allocated in each agreement, and calculated the percentage of such rights won by the pharmaceutical partner. This latter variable (*pharmaPS percentage*) is the principal dependent variable used in this study.[8]

In supplementary analyses, we also include models where the dependent variable is a count of five key biopharmaceutical control rights identified in Lerner and Merges's (1998) influential paper (*pharmaLM5 count*). Apart from reasons of comparability, we include this variable to illustrate how empirical results change depending on the subset of control rights focused on. Finally, we also capture a simple count of the PS control rights won by the pharmaceutical firm (*pharmaPS count*) to contrast the empirical impact of our focus on the share of PS control rights won.

Independent variables

Relative scarcity

Using data from Recap, we measure the availability of pharmaceutical funding with the variable *pharmaceutical funding*, which captures the amount pharmaceutical firms spent annually on biotechnology R&D alliances in billions of dollars (Table 1 presents and defines variables used in this study). The availability of public funding for biotechnology projects is captured by the total amount of money raised in biotechnology IPOs in the previous quarter, again in billions of dollars, and the data for this variable (*previous IPO*) was obtained from Securities Data Corporation (SDC) database. Finally, we captured the availability of late-stage projects by calculating the percentage of alliances in a period that were late-stage alliances, and recorded this value as the variable *lateStage percentage*.

Superior complementarity

Hypotheses 3a–4b predict value appropriation via superior complementarity along two dimensions for biotechnology firms (patent portfolio size and previous R&D experience), and two dimensions for pharmaceutical firms (previous late-stage experience and absorptive capacity). Following Adegbesan's (2009) theory, superior complementarity along each dimension is defined relative to other paired firms (which might not be in our sample). To operationalize these constructs therefore, we compared firms in our sample with firms in *all* the alliances in Recap's database meeting our selection criteria described earlier (a population of 2,284 alliances between 1991 and 2000). Using this data, for each year, we analyzed each firm in each alliance to identify those with the lowest levels of complementarity along each of the four dimensions. We used these minimum values to obtain our measures for superior complementarity as follows:[9]

[8] Please see the Appendix for a more detailed description of our PS control rights and the calculation of our dependent variable.

[9] We would have found it much easier to simply capture 'absolute' values of each complementarity variable without reference

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Table 1. Variables and definitions

Variable	Definition
PharmaPS percentage	Percentage of 'pie-splitting' control rights allocated to the pharmaceutical firm
PharmaPS count	Count of 'pie-splitting' control rights allocated to the pharmaceutical firm
PharmaLM5 count	Count of five key control rights introduced by Lerner and Merges (1998) allocated to the pharmaceutical firm
Pharmaceutical funding	Annual pharmaceutical spending on biotechnology R&D alliances, billions of dollars
Previous IPO	Total biotechnology IPO funds raised in previous quarter, billions of dollars
Previous VC	Total biotechnology funds raised from venture capitalists in previous quarter, billions of dollars
LateStage percentage	Percentage of total projects in the period that are late-stage projects
Superior pharma late-project experience	Measure of pharmaceutical firm experience with late-stage projects relative to the least experienced pharmaceutical firm in that period
Superior pharma absorptive capacity	R&D intensity of pharmaceutical firm in late-stage project divided by that of pharmaceutical firm with lowest R&D intensity in the period
Superior biotech patent portfolio	Measure of biotechnology firm patent portfolio relative to the biotechnology firm with the fewest patents in that period
Superior biotech project experience	Measure of biotechnology firm experience with R&D projects relative to the least experienced biotechnology firm in that period
Pharma pipeline score	Measure of health of pharmaceutical firm's new product pipeline
Pharma pipeline growth	Growth (positive or negative) in *pharma pipeline score* from the previous year
Pharma alliance portfolio	Number of other biotechnology alliances in which pharmaceutical firm is concurrently involved
Biotech shareholders equity	Biotechnology firm shareholder equity, millions of dollars
LateStage	Dummy = 1 if in clinical testing or undergoing regulatory review
RoyaltyPresent	Dummy = 1 if royalty provision is present in contract
EquityInvolved	Dummy = 1 if equity allocation or purchase is present in contract
PriorTie	Dummy = 1 if partners have been involved in a previous alliance
Pharma market cap	Pharmaceutical firm market capitalization, billions of dollars
DealSize	Total alliance payments, millions of dollars

We used data from the U.S. Patent and Trademark Office to identify the number of patents assigned to each biotechnology firm as at the time of signing an alliance. Since the United States is the largest biotechnology market worldwide, virtually all important discoveries are first patented in the United States. In addition, the majority of biotechnology firms in our sample are based in the United States, and so we do not expect any significant bias in this regard. Thus, by subtracting the number of patents assigned to the early-stage biotechnology firm with the fewest patents in each period, from the number assigned to each early-stage biotechnology firm in our sample in that period, we generated the variable *superior biotech patent portfolio*. Additionally, we captured whether or not a biotechnology firm had any patents at signing, using the binary variable *biotechHasPatent*.

We searched Recap to identify previous biotechnology R&D alliances for each firm. By subtracting the number of previous projects carried out by the early-stage biotechnology firm with the lowest number in each period, from the previous number carried out by each early-stage firm in our sample in that period, we created the variable *superior biotech project experience*. In a similar fashion, but focusing on pharmaceutical firms in late-stage projects, we generated the variable *superior pharma late-project experience* that measures how much greater a pharmaceutical firm's previous experience with late-stage projects is, relative to the paired firm with the least experience.

to any other firm. However, for theoretical consistency with Adegbesan's (2009) SFM model, we had to create measures of *superior* complementarity relative to the least valuable paired biotechnology or pharmaceutical firm, as applicable.

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Lastly, using data from Compustat, we captured the absorptive capacity of each pharmaceutical firm involved in a late-stage alliance in each period by means of its R&D intensity (Cohen and Levinthal, 1989; 1990). We divided this figure by the value for the firm with the lowest absorptive capacity in each period to obtain the variable *superior pharma absorptive capacity*.

Bargaining ability

The biotechnology firm's need for external funding is captured by means of the size of its shareholders' equity (*biotech shareholders equity*) in millions of dollars (Higgins, 2007; Lerner and Merges, 1998). We obtained this data from Compustat and from IPO prospectuses. We capture the health of each pharmaceutical firm's pipeline by using data from Pharmaprojects and NDA Pipeline. For every pharmaceutical firm in each year, we identified the number of projects it had at each stage of the regulatory approval process. Following Higgins and Rodriguez (2006), we then weighted and summed these values to generate a measure of pharmaceutical pipeline health called *pharma pipeline score*. As a robustness check, we also identified changes in the pharmaceutical pipeline (positive or negative) from the previous year (*pharma pipeline growth*). Finally, we capture the number of concurrent biotechnology alliances in which each pharmaceutical firm was involved at signing using the variable *pharma alliance portfolio*.

Control variables

Our analysis of the alliance agreements enabled us to detect the presence of royalty payments (*royaltyPresent*) and equity allocations/purchases (*equityInvolved*). While royalties may represent an alternative value appropriation mechanism (Jensen and Thursby, 2001), ownership relationships may affect the nature of bargaining between firms, and so it is important to control for these effects. Additionally, biotechnology firms may also receive funding from venture capitalists, and so we control for this by means of the variable *previous VC* which captures the total amount of biotechnology funding raised via venture capital in the previous quarter.

We control for the total value of alliance payments (*dealSize*) as well as the pharmaceutical firm's size (*pharma market cap*). The total value of alliance payments (i.e., upfront, milestone, and R&D payments) tracks whether the division of PS control rights is determined by the level of pharmaceutical spending, while market capitalization tracks whether it is determined by the pharmaceutical firm's size. Prior ties may also affect the nature of bargaining, and so we control for any previous alliance between partners using the variable *priorTie. PriorTie* and *dealSize* (in millions of dollars) were obtained from Recap, while *previous VC* was obtained from Venture Expert. Market capitalization data (in billions of dollars) was obtained from Compustat. For non-U.S. pharmaceutical firms, share price data and shares outstanding were obtained from Compustat Global. Foreign currencies were converted to U.S. dollars using Compustat Global Currency database with 12 month average exchange rates.

Finally, we control for the heterogeneity of technical risk across alliances by including dummies for the core technology involved in each alliance.[10] To create the dummies, we combined information on the technology and subject from the alliance contracts, with Recap's own technology classification scheme. We sent both categories to two pharmaceutical chemists, who after two independent classification rounds agreed on a reduced six-category classification scheme as follows: diagnostics (*tech_Diagnostics*), drug delivery (*tech_Drug delivery*), proteins and protein-related (*tech_Proteins*), screening (*tech_Screening*), synthetics (*tech_Synthetics*), and vaccines (*tech_Vaccines*). *Tech_Proteins* was the excluded category in our regressions, and so the other technology dummies control for a change in the distribution of PS control rights relative to biopharmaceutical alliances involving proteins and protein-related technologies.

Method

As a result of our fractional dependent variables, we cannot employ ordinary linear regression without implicitly imposing arbitrary limits on the range of variation in our independent variables (Papke and Wooldridge, 1996). We avoid this problem by means of the 'fractional logit' solution introduced by Papke and Wooldridge (1996;

[10] We thank one of the reviewers for suggesting this.

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2008). We implement their solution using *Stata*'s 'generalized linear models' (*glm*) command with a Bernoulli variance function and a logit link function (McDowell and Cox, 2004), which is a standard approach for handling fractional dependent variables (McDowell and Cox, 2004; UCLA, 2007).

To test our hypotheses, we carry out analyses where we interact the variable *LateStage* with our principal dependent variables, as well as analyses where we split our sample into early-stage alliances and late-stage alliances. Interaction terms allow us to capture early- and late-stage effects in the same model, but the high number of product terms can increase the threat of multicolinearity significantly. On the other hand, splitting the sample avoids the threat of multicolinearity from product terms, but reduces the sample size.

To avoid multicolinearity in the model with interaction terms, we centered the interacted variables before computing their products, and avoided using multiple operationalizations of the same constructs (Cohen *et al*., 2002). We also did not interact some of the control variables in order to keep variance inflation factors (VIFs) within range. The individual impact of such variables can be fully understood from the split-sample analyses, which were also used for the comparisons with *pharmaLM5 count* and *pharmaPS count*. For the regressions involving these latter two variables, we utilized negative binomial models, which relax the Poisson assumption of mean/variance equality, and also account for potential omitted variable bias (Cameron and Trivedi, 1986; Hausman, Hall, and Griliches, 1984).

The results from the different analyses are remarkably similar, with only slight differences between them. For the model with interaction terms, the highest VIF is 7.3 and the mean VIF is 3.2. For the split sample analyses, the highest VIF is 4.2 and the mean VIF is 1.9. Thus all the VIFs are well below the recommended ceiling of 10 (Kleinbaum, Kupper, and Muller, 1988), and we are confident that our regressions are able to discriminate between the independent and shared variation in the sample variables.

ANALYSIS AND RESULTS

Descriptive statistics and bivariate correlations are presented in Table 2. Our sample comprises 200 alliances entered into by 43 pharmaceutical firms and 128 biotechnology firms. The average alliance is valued at $65 million.[11] Seventy percent of the alliances are early-stage alliances, 55 percent involve equity stakes, and 23 percent involve partners who have been in a previous alliance together. In 94 percent of the deals, at least nine out of our 10 PS control rights are explicitly allocated between alliance partners, further underlining their importance. On average, pharmaceutical firms win 66 percent of the PS control rights.

The average pharmaceutical firm has a market capitalization of $53 billion, a weighted new product pipeline score of 240 (median of 162), an R&D intensity of 12 percent, and it has been involved in 11 late-stage alliances prior to the focal alliance. Furthermore, the typical late-stage pharmaceutical firm has been involved in nine more late-stage projects than the marginal late-stage pharmaceutical firm, and it has an R&D intensity twice that of the marginal pharmaceutical firm.

On the other hand, the average biotechnology firm has been involved in 19 previous R&D alliances, had 12 patents as at alliance signing, and has a shareholder equity value of $80 million. The mean early-stage biotechnology firm has been involved in 16 more R&D alliances than the marginal early-stage biotechnology firm, and it has 11 more patents than the marginal early-stage biotechnology firm.

The first regressions reported in Table 3 explore variation in the split of PS control rights over the entire sample, showing controls, main effects, and interaction terms.[12] Before going on to discuss our hypothesis tests, three results relevant to our theory can be highlighted.

Firstly, the large and very significant negative effect of *lateStage* ($p < 0.001$) indicates that pharmaceutical firms win a substantially greater share of 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 prized projects and the increased funding options of the biotechnology firms. Secondly, there is a pronounced positive effect of the presence of royalty payments on the split of PS control

[11] All financial values are in constant 2000 dollars.

[12] The prefix 'L_' before a variable name indicates that it has been interacted with *lateStage*. Thus, for example, *L_ pharmaceutical funding* is the product of *lateStage* and *pharmaceutical funding.*

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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	16	17	18
1. PharmaPS percentage	0.66	0.13	0.20	0.90																		
2. LateStage	0.30	0.46	0.00	1.00	−0.39																	
3. Pharmaceutical funding	1.12	0.50	0.18	1.75	0.13	0.06																
4. Previous IPO	0.42	0.44	0.00	1.91	0.07	0.02	0.22															
5. Previous VC	3.26	2.99	0.08	12.79	0.10	0.04	0.59	0.48														
6. LateStage percentage	0.21	0.03	0.16	0.33	−0.05	0.01	−0.48	−0.34	−0.51													
7. Superior pharma late-project experience	8.90	8.10	0.00	31.00	0.18	0.00	0.51	0.22	0.48	−0.25												
8. Superior pharma absorptive capacity	1.99	0.92	1.00	5.36	−0.03	0.04	0.43	0.01	0.41	−0.20	0.31											
9. Pharma pipeline score	240.40	266.86	8.60	1,325.80	0.15	−0.04	0.53	0.26	0.59	−0.38	0.56	0.29										
10. Pharma alliance portfolio	23.29	13.95	1.00	70.00	0.15	−0.05	0.41	0.22	0.39	−0.28	0.50	0.13	0.38									
11. Pharma market cap	53.01	46.16	0.11	216.05	0.19	0.02	0.58	0.30	0.55	−0.34	0.62	0.12	0.51	0.52								
12. Superior biotech patent portfolio	10.78	25.92	0.00	209.00	−0.06	0.08	0.23	0.01	0.25	−0.12	0.05	0.25	0.16	0.05	0.11							
13. BiotechHasPatent	0.62	0.49	0.00	1.00	−0.19	0.19	0.34	0.06	0.25	−0.17	0.04	0.22	0.14	0.06	0.16	0.37						
14. Superior biotech project experience	16.19	17.86	0.00	121.00	−0.06	0.00	0.17	0.00	0.15	−0.10	0.01	0.14	0.12	0.01	−0.07	0.45	0.22					
15. Biotech shareholders equity	79.96	165.00	0.30	1,462.28	−0.13	0.07	0.19	0.18	0.31	−0.24	0.17	0.24	0.27	0.14	0.05	0.45	0.22	0.59				
16. RoyaltyPresent	0.93	0.26	0.00	1.00	0.14	0.01	−0.09	−0.11	−0.18	0.16	−0.15	0.03	−0.07	−0.12	0.01	0.08	0.11	−0.03	−0.01			
17. DealSize	65.42	88.85	1.60	815.00	−0.12	0.18	0.26	0.03	0.23	−0.10	0.12	0.10	0.33	0.12	0.07	0.20	0.18	0.26	0.37	0.07		
18. EquityInvolved	0.55	0.50	0.00	1.00	−0.10	0.06	−0.17	−0.14	−0.18	0.13	−0.07	−0.03	−0.22	0.00	−0.21	−0.10	−0.14	−0.04	−0.14	0.15	0.06	
19. PriorTie	0.23	0.42	0.00	1.00	−0.06	0.00	0.08	0.01	0.02	−0.09	0.07	−0.01	0.11	0.17	0.06	0.01	0.08	0.27	0.05	−0.08	0.02	−0.08

n = 200.

Table 3. Results of regression analyses for overall sample[a]

PharmaPS percentage	Model 1: controls only		Model 2: main effects		Model 3: complete model	
Constant	**0.610*****	(0.151)	**0.663*****	(0.137)	**0.943*****	(0.147)
LateStage	**−0.367*****	(0.091)	**−0.303****	(0.096)	**−0.851*****	(0.226)
Pharmaceutical funding			0.428	(0.279)	0.453	(0.268)
L_Pharmaceutical funding					**0.691***	(0.331)
LateStage percentage			2.338	(1.543)	−0.402	(1.887)
L_LateStage percentage					**8.158*****	(3.004)
Previous IPO			0.135	(0.126)	0.172	(0.143)
L_Previous IPO					−0.321	(0.200)
Superior biotech patent portfolio			0.001	(0.001)	0.001	(0.001)
L_Superior biotech patent portfolio					0.004	(0.003)
BiotechHasPatent			**−0.291****	(0.110)	**−0.386****	(0.125)
L_BiotechHasPatent					0.278	(0.198)
Superior biotech project experience			0.007	(0.004)	−0.004	(0.004)
L_Superior biotech project experience					0.007	(0.005)
Superior pharma late-project experience			0.011	(0.008)	3.4E-04	(0.008)
L_Superior pharma late-project experience					**0.024***	(0.014)
Superior pharma absorptive capacity			−0.111	(0.048)	−0.069	(0.053)
L_Superior pharma absorptive capacity					−0.103	(0.105)
Biotech shareholders equity			−5.0E-04	(3.5E-04)	−5.3E-05	(3.7E-04)
Pharma pipeline score			3.0E-04	(3.7E-04)	**4.9E-04**†	(3.0E-04)
Pharma alliance portfolio			−0.001	(0.004)	0.007	(0.005)
L_Pharma alliance portfolio					−0.018	(0.008)
RoyaltyPresent	0.229	(0.143)	**0.349****	(0.106)	**0.233****	(0.088)
EquityInvolved	−0.082	(0.078)	−0.083	(0.087)	**−0.311****	(0.119)
L_EquityInvolved					**0.686****	(0.200)
Previous VC			−0.022	(0.028)	**−0.047**†	(0.028)
DealSize	−4.8E-04	(3.7E-04)	**−0.001**†	(4.4E-04)	3.5E-04	(4.8E-04)
L_DealSize					**−0.005*****	(0.001)
PriorTie	−0.125	(0.087)	−0.158	(0.102)	−0.156	(0.096)
Pharma market cap	**0.003****	(0.001)	8.9E-05	(0.001)	−0.002	(0.001)
Tech_Diagnostics	−0.146	(0.139)	−0.125	(0.141)	−0.163	(0.134)
Tech_Drug delivery	−0.174	(0.153)	−0.152	(0.174)	−0.079	(0.181)
Tech_Screening	**0.325*****	(0.093)	**0.335****	(0.118)	**0.375****	(0.113)
Tech_Synthetics	0.032	(0.120)	−0.078	(0.130)	−0.054	(0.125)
Tech_Vaccines	**−0.321***	(0.162)	**−0.453****	(0.173)	**−0.451****	(0.158)
Log pseudo-likelihood	−80.489		−65.166		−64.273	
Wald χ^2	72.34***		147.43***		317.01***	

[a] Generalized linear models (using a Bernouli variance function and a logit link function). Robust standard errors in parentheses.
† $p < 0.10$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
$n = 200$.

rights. *RoyaltyPresent* is positive and significant ($p < 0.01$), meaning that pharmaceutical firms win a larger share of PS control rights when they pay royalties. This suggests that they are willing to pay royalties in return for more PS control rights, supporting our view of PS control rights as a mechanism for splitting the pie. Finally, the consistent significance of *tech_Screening* ($p < 0.01$) and *tech_Vaccines* ($p < 0.01$) underlines the importance of controlling for technical characteristics. Pharmaceutical firms win more of the PS control rights in alliances to screen chemical compounds, a process that is usually technically less complex than the development of new vaccines where biotechnology firms win more of the PS control rights.

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Table 4. Results of regression analyses for early-stage alliances[a]

Independent variables	Model 4: *pharmaPS percentage* (GLM[b])		Model 5: *pharmaLM5 count* (Negative binomial)		Model 6: *pharmaPS count* (Negative binomial)	
Constant	**0.850*****	(0.194)	0.803**	(0.286)	1.670***	(0.115)
Pharmaceutical funding	0.335	(0.183)	0.045	(0.119)	0.003	(0.072)
Superior biotech patent portfolio	0.001	(0.001)	−0.003**	(0.001)	−0.001	(0.001)
BiotechHasPatent	**−0.420****	(0.121)	−0.037	(0.072)	−0.043	(0.046)
Superior biotech project experience	**−0.009***	(0.004)	3.2E-05	(0.003)	−0.002	(0.002)
Biotech shareholders equity	2.9E-04	(3.7E-04)	−0.001†	(4.0E-04)	−3.0E-05	(1.6E-04)
Pharma pipeline score	−0.040	(0.022)	−0.029	(0.028)	−0.011	(0.009)
Pharma alliance portfolio	**0.009***	(0.004)	0.005†	(0.003)	0.002	(0.001)
RoyaltyPresent	**0.329***	(0.154)	0.623*	(0.289)	0.280**	(0.108)
EquityInvolved	**−0.364****	(0.114)	−0.143†	(0.075)	−0.088†	(0.049)
PriorTie	−0.066	(0.116)	−0.154	(0.100)	−0.056	(0.053)
Pharma market cap	−0.001	(0.001)	−0.001	(0.001)	−2.1E-04	(0.001)
Previous VC	−0.021	(0.033)	0.050*	(0.023)	0.016	(0.014)
LateStage percentage	−1.443	(1.802)	−1.224	(1.397)	−0.428	(0.729)
DealSize	0.001	(0.001)	2.7E-04	(3.1E-04)	2.4E-04	(2.1E-04)
Tech_Diagnostics	−0.095	(0.148)	0.038	(0.175)	−0.013	(0.077)
Tech_Drug delivery	0.060	(0.229)	−0.126	(0.183)	−0.050	(0.098)
Tech_Screening	**0.356****	(0.121)	0.206**	(0.078)	0.100*	(0.048)
Tech_Synthetics	−0.003	(0.146)	−0.022	(0.108)	0.024	(0.057)
Tech_Vaccines	−0.091	(0.183)	−0.284	(0.277)	−0.057	(0.088)
Log pseudo-likelihood	−41.413		−177.679		−194.656	
Wald χ^2	85.98***		48.67***		50.64***	

[a] Robust standard errors are in parentheses.
[b] Generalized Linear Model (utilizing a Bernouli variance function and a logit link function).
† $p < 0.10$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
$n = 140$.

Early-stage alliances

The results in Model 4 of Table 4 explore the division of PS control rights in early-stage alliances, and we find support for our hypotheses on the effects of superior complementarity and bargaining ability. The variable *superior biotech project experience* is negative and significant ($p < 0.05$), which suggests that even though pharmaceutical firms are in a stronger overall position in early-stage alliances, biotechnology firms with superior experience retain more PS control rights from their pharmaceutical partner. Thus, Hypothesis 3b is supported. Similarly, *biotechHasPatent* is negative and significant ($p < 0.01$), suggesting that biotechnology firms with patents retain more of the PS control rights than those that have none. Nevertheless, this only provides partial support for Hypothesis 3a, where we had expected superior complementarity to be related to the *number* of patents a biotechnology firm had. Instead, it turns out that what pharmaceutical firms seem to value is whether a biotechnology firm has patents or not.

With respect to bargaining ability, *pharma alliance portfolio* is positive and significant ($p < 0.05$). This suggests that pharmaceutical firms involved in a greater number of concurrent alliances are able to extract more value from their biotechnology partner, thus supporting Hypothesis 5c.

However, relative scarcity (Hypothesis 1) does not seem to be an important driver of value distribution within early-stage alliances. This may mean that there is very little difference in quality among the biotechnology firms that do not get funded. Consequently, variation in the availability of pharmaceutical funding will have a limited effect on variation in the allocation of PS control rights.[13]

[13] Recall from our earlier discussion, that if unfunded biotechnology firms are similar in complementarity, then s_0 in Figure 1

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Table 5. Results of regression analyses for late-stage alliances[a]

Independent variables	**Model 7: *pharmaPS percentage*** (GLM[b])		**Model 8: *pharmaLM5 count*** (Negative binomial)		**Model 9: *pharmaPS count*** (Negative binomial)	
Constant	0.114	(0.175)	0.990***	(0.180)	1.585***	(0.101)
Pharmaceutical funding	**1.410***	(0.637)	0.882**	(0.339)	0.694**	(0.139)
Previous IPO	−0.181	(0.145)	−0.101	(0.158)	−0.082†	(0.048)
LateStage percentage	**7.163****	(2.397)	10.960***	(2.167)	3.456**	(1.059)
Superior pharma late-project experience	**0.032****	(0.012)	0.010	(0.014)	0.014**	(0.005)
Superior pharma absorptive capacity	−0.216	(0.204)	−0.096	(0.120)	−0.125	(0.144)
Biotech shareholders equity	0.001	(0.001)	−1.8E-04	(0.001)	3.8E-04	(3.1E-04)
Pharma pipeline score	**0.001**†	(4.0E-04)	0.001	(4.8E-04)	4.0E-04*	(1.9E-04)
Pharma alliance portfolio	−0.015	(0.008)	0.006	(0.009)	−0.008	(0.005)
Previous VC	**−0.082***	(0.042)	−0.029	(0.043)	−0.034*	(0.017)
RoyaltyPresent	0.194	(0.122)	0.095	(0.200)	0.123	(0.093)
EquityInvolved	**0.520****	(0.161)	0.001	(0.159)	0.208**	(0.068)
DealSize	**−0.004*****	(0.001)	−0.005***	(0.001)	−0.002***	(3.5E-04)
PriorTie	−0.279	(0.186)	−0.060	(0.167)	−0.106	(0.081)
Pharma market cap	−0.001	(0.002)	−0.001	(0.002)	−0.001	(0.001)
Tech_Diagnostics	−0.125	(0.173)	0.171	(0.168)	−0.042	(0.074)
Tech_Drug delivery	**−0.588***	(0.241)	−0.570	(0.398)	−0.270*	(0.109)
Tech_Screening	**0.766****	(0.253)	0.462†	(0.260)	0.336**	(0.103)
Tech_Synthetics	**−0.378***	(0.186)	−0.371*	(0.164)	−0.149*	(0.070)
Tech_Vaccines	**−0.919****	(0.270)	−0.110	(0.238)	−0.477**	(0.129)
Log pseudo-likelihood	−22.809		−81.352		−96.327	
Wald χ^2	789.24***		421.74***		221.01***	

[a] Robust standard errors are in parentheses.
[b] Generalized linear model (utilizing a Bernouli variance function and a logit link function).
† $p < 0.10$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
$n = 60$.

With respect to our control variables, the substantial negative impact of *equityInvolved* ($p < 0.01$) suggests that pharmaceutical firms win fewer of the PS control rights when they own part of the biotechnology firm. As such, ownership ties seem to restrain the force of bargaining in early-stage alliances where pharmaceutical firms have a stronger position overall. *RoyaltyPresent* is also significant ($p < 0.05$), and its positive sign continues to indicate pharmaceutical firms win more of the PS control rights when they pay royalties. Finally, the positive sign on *tech_Screening* ($p < 0.01$) suggests that pharmaceutical firms win a greater share of PS control rights in alliances to carry out compound screening.

Therefore, our overall results suggest that while pharmaceutical firms appropriate more value in early-stage than in late-stage alliances, variation within early-stage deals is driven mostly by biotechnology firms' ability to retain PS control rights through their superior complementarity and the issuance of equity to their partners.

Late-stage alliances

Model 7 in Table 5 explores the outcome of bargaining over PS control rights in late-stage alliances, and our results show support for hypotheses on relative scarcity, superior complementarity, and bargaining ability. Due to its larger sample size, however, we will concentrate our discussion on Model 3 in Table 3 (except for *pharma pipeline score* and *previous VC,* which do not have interaction terms in Model 3). The late-stage results are identical across both models.

(the amount of surplus that the best unfunded firm could create with pharmaceutical dollars) will vary little with variation in the availability of funding (Adegbesan, 2009), thereby weakening the effect of relative scarcity.

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Starting with relative scarcity, the sum of *lateStage percentage* and *L_lateStage percentage* is positive and significant ($p < 0.001$), thus supporting Hypothesis 2a that predicted that increased availability of late-stage projects would favor pharmaceutical firms. However, although the sum of *previous IPO* and *L_previous IPO* is negative as predicted in Hypothesis 2b, it is not significant, suggesting that variation in the availability of public funding may not affect the distribution of PS control rights in late-stage alliances.

With respect to the impact of superior complementarity, the sum of *superior pharma late-project experience* and its interaction with *lateStage* is positive and significant ($p < 0.05$), suggesting that pharmaceutical firms with greater late-stage experience retain more of the PS control rights in late-stage alliances, as predicted by Hypothesis 4a. However, we do not find a significant effect for superior absorptive capacity (Hypothesis 4b).

For bargaining ability, while *pharma pipeline score* (Model 7) is weakly significant ($p < 0.1$), its positive sign suggests that pharmaceutical firms with healthier new product pipelines are able to win a greater share of PS control rights. This thus provides some support for Hypothesis 5b.

As regards our control variables, we find a very significant increase ($p < 0.001$) in the share of PS control rights won by biotechnology firms in larger late-stage deals (the sum of *dealSize* and *L_dealSize* is negative). Thus, rather than pharmaceutical firms spending more to win more PS control rights, it is in fact biotechnology firms that win more PS control rights in larger *late-stage* deals. A closer analysis of this interesting result reveals that the average deal size is strongly correlated with the closeness of late-stage projects to regulatory approval.[14] Recalling that further advanced projects are dramatically scarcer, yet much more attractive to pharmaceutical firms, like Higgins (2007) we interpret this result as capturing a reinforcement of the biotechnology firms' stronger position in late-stage alliances, as projects advance toward regulatory approval. This is also supported by the fact that *dealSize* is not significant in early-stage alliances (see Higgins (2007: 69) for a more detailed discussion of this effect).

Another interesting result is that the late-stage impact of *equityInvolved* is positive and again significant at the one percent level. As such, while the presence of an equity relationship restrained the bargaining power of pharmaceutical firms in early-stage deals, it restrains the bargaining power of biotechnology firms here. Thus, the presence of equity seems to dampen the bargaining power of the dominant partner in each context. This is in contrast to *priorTie* which had no impact on the division of PS control rights in either context. While previous studies show that prior (collaborative) ties aid coordination and efficiency (Ariño and Reuer, 2005; Mayer and Argyres, 2004; Reuer and Ariño, 2007), it would seem to be *ownership* ties that affect value appropriation.

Finally, *previous VC* (Model 7) is negative and significant ($p < 0.05$). This suggests that since variation in public funding did not significantly affect the distribution of PS control rights in late-stage alliances, venture capital may be the relevant source of alternative funding for biotechnology firms with late-stage projects. Thus we find that when biotechnology firms raise more money from venture capitalists in the previous quarter, pharmaceutical firms win a smaller share of the PS control rights in late-stage alliances.

Overall, therefore, our results suggest that biotechnology firms win more PS control rights in late-stage alliances, and that this effect is accentuated as projects progress in the development process, as late-stage projects become scarcer, or as venture capital is more available. Nevertheless, pharmaceutical firms are able to retain a significant portion of the PS control rights through their superior complementarity, bargaining ability, or the purchase of equity in their partner.

One last point relates to the supplementary regressions in Tables 4 and 5. When we carry out our analyses using a count of five key biopharmaceutical control rights (*pharmaLM5 count*) from Lerner and Merges (1998), we find that different independent variables are significant, or the same variables have different levels of significance or even different signs. The modest point to be made here is that the choice of the subset of control rights used is important, and should be theory driven. Similarly, different results are obtained when using a *count* of PS control rights (*pharmaPS count*) as opposed to a *split* (which is what our theory predicts).

[14] On average, *dealSize* increases by about 45 percent across each phase of clinical testing. The average deal in first-round clinical testing is worth \$60m, while the average deal in final-round testing is worth \$125m.

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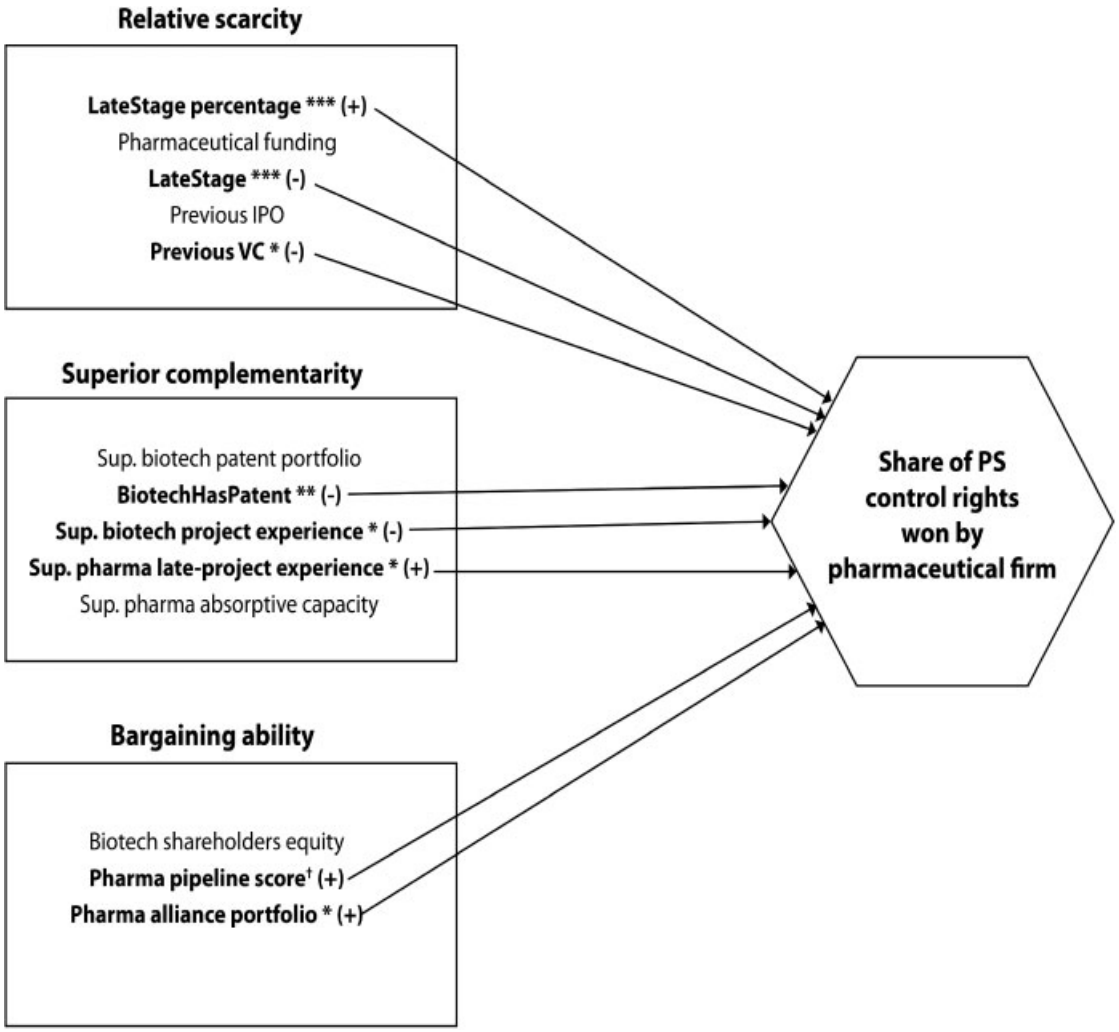

Figure 2. Summary of results

In summary therefore, as shown in Figure 2, our results support the importance of relative scarcity, superior complementarity, and bargaining ability, as drivers of intra-alliance value division.

DISCUSSION AND CONCLUSION

We started this paper by highlighting a gap in our understanding of the determinants of the division of value created by an alliance between the partners to its creation. Although we have a well-developed understanding of value creation in strategic alliances, there is a gap in our understanding of intra-alliance value appropriation. Bridging this gap is an important antecedent to a consistent theory of value creation *and* appropriation in strategic alliances (Dyer and Singh, 1998).

As a small step in this direction, we suggest 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 can be predicted by an extension of SFM theory proposed by Adegbesan (2009).

Applying this model to the empirical setting of biotechnology R&D alliances, we measured relative scarcity, relative bargaining ability, and superior complementarity in terms of firm-level

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and industry-level variables, which we then used to predict variation in value appropriation across alliance partners, partner types, and individual firms of each type.

Our findings suggest a definite impact of relative scarcity, superior complementarity, and bargaining ability in early-stage and late-stage alliances. In early-stage alliances, biotechnology firms give up substantially more PS control rights than they do in late-stage deals, while in late-stage alliances pharmaceutical firms give up more PS control rights when promising projects are less available. Nevertheless, firm-specific superior complementarity allows some partners to improve their value appropriation even in the face of unfavorable scarcity effects. Thus, in early-stage alliances, biotechnology firms with patents or with superior project experience retain more PS control rights, while in late-stage alliances, pharmaceutical firms with superior late-stage experience retain more PS control rights.

The importance of firm-specific resources and capabilities is significant, given the growing impact of industry-level factors over the period spanned by our sample. For example, our data show that as the number of R&D alliances has greatly increased over time, the average percentage of PS control rights won by biotechnology firms in early-stage alliances has been falling. Similarly, despite growth in the overall number of alliances, the total number of late-stage projects has remained fairly constant, causing a progressive fall in the percentage of late-stage projects over time. Thus, superior complementarity becomes even more critical for biotechnology or pharmaceutical firms wishing to buck these trends and be assured of significant value appropriation. Bargaining ability also plays an important role, and we find that pharmaceutical firms with larger alliance portfolios or healthier new product pipelines win a greater share of PS control rights from their biotechnology partners.

Overall, therefore, we feel confident in 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 great its bargaining ability is relative to its alliance partner.

Consequently, we believe that our study makes several important contributions. First, in exploring determinants of the division of relational rents between alliance partners, we show how value appropriation is contingent on the circumstances surrounding alliance creation, and we underline the importance of firm bargaining position in this respect. Our study highlights the fact that alliances often take place in the context of wider markets for alliance partners, where prevailing conditions of supply and demand interact with firm-specific resource and capability endowments to determine how much each firm benefits from collaboration. Heightened consciousness of the fact that potential partners have alternatives, will lead firms to evaluate critically what—and how much—relative value they bring to the negotiating table, and this should help them improve their choice of strategic alliance partners.

Second, our focus on bargaining position indicates a potentially fruitful indirect approach for tackling the thorny question of the determinants of the impact of strategic alliances on the performance of individual firms. Since alliance effects are difficult to isolate from other potential drivers of firm performance, analysis of the amount of value firms appropriate from strategic alliances can provide an alternative route, under *ceteris paribus* assumptions.

A third contribution of this paper is our measure of value appropriation. Since important control rights are usually specified in filed alliance contracts, our proxy is readily accessible to most researchers. In addition, our measure captures a direct outcome of the alliance bargaining process, as opposed to a *reaction* to that outcome, such as a stock price appreciation or depreciation. Furthermore, the *split* of PS control rights implicitly considers the relative performance of both partners simultaneously.

Fourth, our paper links the growing literature on alliance contractual design with the literature on alliance performance. However, we stress the importance of recognizing causal heterogeneity in the allocation of different alliance control rights and other contractual clauses. Therefore, researchers should focus on the 'correct' subset of contractual terms depending on the theoretical mechanisms being studied. Finally, our paper adds to the very limited pool of empirical studies of SFM theory, possibly the last remaining underexplored frontier of the resource-based view.

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Limitations and future research

Like all papers, ours suffers from some limitations. First, by proxying value appropriation with the distribution of a subset of control rights, we may not capture some other valuable elements that are also important to alliance partners. In addition, the applicability of our empirical approach may be limited to alliances that include an explicit division of responsibilities and benefits (most technology alliances, for example). Nonetheless, as we pointed out earlier in the paper, control rights have been studied in a wide range of industries and empirical settings, and our only innovation has been to focus on those rights, which we argue are related to value appropriation rather than other mechanisms such as, for example, protection against potential opportunistic behavior. Finally, value appropriation is not independent of value creation, and so it would be desirable to capture the dynamics of alliance value creation more explicitly.

Overall therefore, we believe that this study indicates fruitful directions for future research. From an empirical standpoint, we sought to contribute with a tractable measure of value appropriation. In furthering this task, future studies could profitably develop and explore PS control rights in other industry contexts. Alternatively, researchers could continue to seek out other measures of value appropriation amenable to empirical analysis. At the same time, beyond our focus on value appropriation, our analysis also suggests that some other subsets of contractual clauses could be used for testing predictions from various theoretical perspectives such as property rights theory, transaction cost economics, the resource-based view, the relational view, and so on.

From a theoretical standpoint, there is an urgent need for further analysis of the interaction between value creation and value appropriation imperatives in strategic alliances. Do firms choose to ally with partners with which they can create the largest 'pie,' or partners with which they can appropriate the largest 'slice of the pie'? Do different types of alliances, (e.g., exploration vs. exploitation) differ in their value creation and value appropriation outcomes? How do firms handle these trade-offs? Do dominant firms cede in appropriation in order to incentivize weaker partners, or is value appropriation about unrestrained competition?

We also believe that the concept of superior complementarity is ripe for further analysis. Given its critical impact in sourcing from SFM, future work could explore its antecedents, accumulation/acquisition, and maintenance. Finally, future studies could attempt to characterize the relationship between value appropriation and firm performance. This would fully open the way to more studies exploring the impact of strategic alliances on firm performance, via their value appropriation outcomes.

In conclusion, we believe that our study opens up many exciting vistas for future work, and we seek to stimulate further theoretical refinement and empirical investigation in this critical area of research.

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APPENDIX: 'PIE-SPLITTING' CONTROL RIGHTS

PS control rights are those that confer ownership and control over activities and intermediate outputs that directly affect the allocation of portions of the overall value to be created by an alliance.

As an illustration, pharmaceutical firms sometimes win a right to unconditional termination of an alliance, along with control of any research results generated up to the point of termination. The allocation of this control right to the pharmaceutical firm serves to discourage the biotechnology firm from using the funding it receives to pursue other research projects beyond the scope of the alliance (Lerner and Malmendier, 2010). Consequently, this control right is clearly not pie splitting, but serves to align *ex post* behavior efficiently. In contrast however, the vast majority of biopharmaceutical alliances allocate ownership (shared or sole) of patents that may be generated in the course of the collaboration. This right thus guarantees at least partial ownership of income streams that may accrue in the event of successful research, and is therefore clearly a pie-splitting control right.

To identify which control rights are pie splitting in the context of biotechnology R&D alliances, we carried out an exhaustive review of all the control rights that have been used in the literature, combined with discussions with industry practitioners. In this way, we identified the following 10 PS control rights for biotechnology R&D alliances:

Intellectual property rights

1. *Partial patent ownership:* Shared ownership of patents arising from the alliance.
2. *Exclusive patent ownership*: Exclusive ownership of patents arising from the alliance.
3. *Right to transfer of unpatented 'know-how'*: The right to share in any unpatented intellectual property generated during the alliance.
4. *Ownership of unpatented 'know-how'*: Outright ownership of all unpatented intellectual property generated during the alliance.

Licensing rights

5. *Right to sublicense*: The right to sublicense alliance technology to other firms.
6. *Continued licensing rights on expiration:* The right to continue selling products based on alliance technology beyond the term of the agreement.

Manufacturing rights

7. *Right to manufacture final product*: Control of manufacturing (process technology and manufacturing facilities) after regulatory approval.

Marketing rights

8. *Basic marketing rights:* The right to play a role in marketing the final product.
9. *Universal marketing rights*: No geographical territories, disease indications or products are reserved exclusively for the biotechnology firm.
10. *Control of entire marketing process*: The biotechnology firm does not retain a right to participate in the marketing process via co-promotion or co-marketing.

Lerner and Merges (1998) identified 25 prevalent biopharmaceutical control rights; Higgins (2007) identified 10 important biopharmaceutical control rights; and Lerner *et al*. (2003) used five key biopharmaceutical control rights. Since we focus only on *pie-splitting* control rights, our rights are a subset of those identified in these papers. Of our 10 PS control rights, eight (1–5, 7, and 9–10) are included in the 25 control rights identified by Lerner and Merges (1998), while one other control right (basic marketing rights) was uncovered by Higgins (2007). Our final PS control right (continued licensing rights on expiration) was isolated as a result of discussions with practitioners who highlighted a distinction between continued rights on *expiration*, and continued rights on *termination*.[15]

To calculate the share of PS control rights won by each partner, we started by identifying the number of our 10 PS control rights allocated in each alliance. The typical legal treatment of technology licenses reserves for the licensor any rights

[15] While the former responds to pie-splitting concerns, the latter responds to governance concerns. Lerner and Merges (1998) combine a right to continued licensing on termination *or* expiration; while Higgins (2007) focuses only on a right to continued licensing on alliance termination.)

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not explicitly granted to the licensee. In this spirit, we coded the PS control rights from the point of view of the pharmaceutical firm (i.e., which rights it manages to win from the biotechnology firm). Considered in this way, some of the PS control rights are binary, while the others are cumulative.

For binary PS control rights, one partner wins or retains the right, to the exclusion of the other (e.g., either the biotechnology partner or the pharmaceutical partner may win the right to manufacture the final product). In this sense, the binary PS control rights are: the right to sublicense (right 5), continued license rights on expiration (right 6), and the right to manufacture the final product (right 7).

On the other hand, for cumulative PS control rights, a greater or lesser portion of a subset of rights may be won by the pharmaceutical firm, with the residual portion retained by the biotechnology firm. For example, if the pharmaceutical firm wins right 3, but not right 4, then the biotechnology firm retains ultimate ownership of any unpatented intellectual property generated during the alliance. However, if the pharmaceutical firm wins both rights 3 and 4, then the biotechnology firm retains no residual ownership of the unpatented intellectual property. Thus, the (three) sets of cumulative PS control rights are: *partial* to *exclusive* patent ownership (rights 1–2); *transfer* to *ownership* of unpatented 'know-how' (rights 3–4); and *basic* to *total* marketing rights (rights 8–10).

Consequently, in either case, the greater the number of PS control rights allocated in a deal that are won by the pharmaceutical firm, the greater the share of the pool of PS control rights it wins. For each alliance, therefore, we counted the number of PS control rights won by the pharmaceutical firm, and divided this figure by the total number of PS control rights allocated in that alliance, in order to generate *pharmaPS percentage*, our principal dependent variable. We found that at least nine out of our 10 PS control rights were explicitly allocated in 94 percent of the alliances in our sample, and the share won by the pharmaceutical partner ranged from 20 percent to 90 percent, with a mean of 66 percent.

Finally, it is pertinent to note that since our data enabled us to capture and code *all* the rights used by previous authors, our choice of PS control rights was strictly theory driven. Furthermore, we also identified two other broad classes of control rights (operational/coordination control rights and safeguards) that we intend to explore further in future work.

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