A Multi-Dimensional View of Alliance Complexity and Value Division in Technology Sourcing Agreements*

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Abstract: Most research on alliances ignores the structures of the underlying relationships as codified by contract. By overlooking these structures the complexity of the fundamental relationship is ignored. This is problematic since it is how these relationships are codified and how control rights are allocated that dictate *how* firms will benefit (or not) from an alliance. We present a novel method to analyze the determinants of alliance complexity in a multi-dimensional framework. We then look at the effect these same determinants have on the allocation of control rights between firms. From a transaction cost perspective we can begin to look at the cost/benefit of entering more (or less) complex agreements in terms of the allocation of rights (i.e., value appropriation). This approach provides a new framework in which to begin to think about the net effect alliance portfolios have on a firm.

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1.0 Introduction

There exists an extensive literature, spanning multiple disciplines, focusing on strategic alliances. Researchers have explored, for example, why firms engage in alliances; how partners are chosen; what types of alliances are entered; the impact on innovation and new product development; and whether alliances create value for shareholders. Often overlooked, however, in these literatures are the structures of the underlying relationships as codified by contract. By overlooking these structures the complexity of the fundamental relationship is ignored. This is problematic since it is how these relationships are codified and how control rights are allocated that dictate how firms will benefit (or not) from an alliance (Adegbesan and Ricart, 2005; Adegbesan and Higgins, 2007).

There is a rich literature dealing with contract structure (e.g., Williamson, 1985, 1991; Granovetter, 1985; Joskow, 1987; Joskow, 1988; Bradach and Eccles, 1989; Pisano, 1989; Gulati, 1995; Uzzi, 1997; Oxley, 1997; Dyer and Singh, 1998; Bernheim and Whinston, 1998; Adler, 2001; Poppo and Zenger, 2002; Sampson, 2004; Ryall and Sampson, 2006; Barthelemy and Quelin, 2006). Transaction Cost Economics (TCE) scholars, for example, argue that contracts will be more "complex" in order to mitigate potential exchange hazards (Williamson, 1985, 1991). When these potential exchange hazards are low complex contracts are not needed and simpler, more routine ones are sufficient (Joskow, 1987). A complementary but distinct set of research concentrates on the underlying allocation of specific control rights identified in a contract (e.g., Lerner *et al*, 2003; Lerner and Merges, 1998; Elfenbein and Lerner, 2003; Lerner and Malmendier, 2004; Higgins, 2007a; Adegbesan and Higgins, 2007). Although these studies make important contributions to the literature, they tend to only analyze how rights *within* an existing structure are allocated and overlook the importance of the structure itself whereas the complexity literature tends to focus on contract structure while ignoring the underlying allocation of rights.

We are not aware of any research that explores the relationship between these two distinct literatures; we make a first attempt at bridging them together. Understanding this linkage is important for several reasons. First, many technology sourcing contracts, especially within the biopharmaceutical industry, are becoming more standardized and include very similar contractual terms (Higgins, 2007a),

yet the underlying relationship can be very diverse and how a firm benefits from the alliance can come in numerous ways. Second, contracting involves costs and tradeoffs. Understanding these potential costs and tradeoffs are important to managers when faced with making decisions that involve the complexity of an alliance relationship. By considering complexity and control rights together the true cost of contracting can be analyzed. For example, from a transaction cost perspective, writing a complex contract is costly. However, if that same firm is able to appropriate significant value in terms of the underlying allocation of control rights then the "cost" of contracting, potentially, becomes a net positive for the firm. It may pay for firms to write more or less complex contracts.

We make several contributions to the literature. First, we model alliance complexity in a multi-dimensional framework and investigate the link between alliance complexity and contract structure. This framework allows us to focus on both the functional scope and the technological scope of an agreement. Functional scope provides us with a measure of the *depth* of an alliance while technological scope provides us with a measure of the *breadth* of an alliance. Second, within this framework, we analyze the determinants that increase the probability that an alliance agreement will be more functionally and/or technologically complex. We find that one of the most significant factors that increase the complexity of an agreement are the age and prevalence of the technology and the stage of development of the focal product at the time of signing. New and less prevalent technologies can be viewed as more risky while products in later stages of development can be viewed as less risky. Both have implications for the complexity of the alliance contract.

Third, complexity is not determined in a vacuum; there are costs and trade-offs associated with firm choices. Our findings suggest that there is a tradeoff to firms for engaging in more complex relationships in terms of value appropriation (proxied by the allocation of control rights) with respect to specific payment terms. These findings contribute to the control rights literature that largely ignores the underlying structure of the actual agreement.

Finally, we find that a firm's prior relationships with a partner have a negative effect on complexity. This suggests that prior and repeated relationships not only reduce contractual safeguards, as

found in previous research (Ciccotello and Hornyak, 2000, Parke, 1993, and Gulati, 1995), but the need to engage in a functionally and technologically detailed relationship is reduced as well.[1] Prior research that finds evidence of reduced contractual safeguards between firms engaging in repeated contacts attributes their findings to increased levels of trust (Granovetter, 1985; Bernheim and Whinston, 1998; Bradach and Eccles, 1989; Dyer and Singh, 1998; Gulati, 1995; Uzzi, 1997; Adler, 2001; Poppo and Zenger, 2002; Gulati and Nickerson, 2007). Our research shows that trust established through prior research can also shape the underlying complexity of future alliances. Interestingly, however, we find that neither prior relationships nor repeated contacts have any effect on how rights are divided between firms. So while relational norms appear to influence the complexity of an alliance structure, the actual allocation of rights and as a result value appropriation, is unaffected. Trust only goes so far.

The remainder of the paper is organized as follows. Section 2 discusses our framework for contractual complexity and control rights; Section 3 discusses our data and sample construction; Section 4 presents and discusses our empirical finding; and, Section 5 summarizes the analysis and discusses extensions of this research.

2.0 Prior Research, Theory and Hypothesis Development

2.1 Determinants of complex relationships

There is a large and growing literature in organizational economics and strategic management on contract structure and contractual complexity in formal organizational forms such as strategic alliances (e.g., Reuer and Arino, 2007; Robinson and Stuart, 2007; Barthelemy and Quelin, 2006; Ryall and Sampson, 2006; Oxley and Sampson, 2004; Luo, 2002; and, Poppo and Zenger, 2002; Joskow, 1988). Formal contractual agreements form the basis for quasi-organizational structures such as strategic alliances by establishing rights and responsibilities of the partner firms. These formal contractual agreements are negotiated *both* to provide incentives in a cooperative environment and to protect against potential opportunistic behavior. The complexity of the relationship's undertaking influences the terms of

[1] Ryall and Sampson (2006) recently find that contracts are more detailed when firms have prior relationships in contrast to other previous research.

these formal agreements. For example, the uncertainty and difficulty of the technological undertaking in an alliance will influence the contract structure and potentially the bargaining position of the firms. From a transaction cost theory perspective this uncertainty, in the presence of relationship specific investment, would be considered as an exchange hazard necessitating the need for more complex agreements (Williamson, 1985, 1991). When the likelihood of exchange hazards is low the associated costs of complex contracts are not necessary and relatively simple ones are sufficient (Joskow, 1987).

However, broad measures such as contract length or the number of provisions included in a contract (Joskow, 1988; Robinson and Stuart, 2007) do not consistently define contractual complexity across heterogeneous contractual relationships. Moreover, focusing only on certain provisions may be too limited and ignore other relevant aspects of contractual design (Reuer and Arino, 2007). As such, we first seek to understand the determinants of complexity and then we investigate their effect on how the underlying contractual rights are allocated between firms. By considering both the potential cost of contracting due to complexity and the impacts on control rights (value-appropriation) we gain a holistic view of the cost/benefit of engaging in alliances to a firm. Instead of viewing alliances in a "black box" we are able to begin to understand more fully their potential impact on a firm.

We define alliance complexity along a multidimensional framework: functional scope and technological scope (discussed more fully below). Functional scope provides us with a measure of the *depth* of an alliance contract while technological scope provides us with a measure of the *breadth* of an alliance contract. More specifically, functional scope identifies the extent of value chain activities, such as manufacturing and marketing, are specified in technology sourcing agreements. This measure of the *depth* is similar to the alliance scope definition in Oxley and Sampson (2004). Technology scope or the number of technologies that are specified in an alliance defines the *breadth* dimension of our notion of

alliance complexity.[2] [3] Technological complexity, especially in research-intensive alliances, is particularly relevant since it relates to firm capabilities and the overall uncertainty of the focal projects.

Thus, our definition of alliance complexity is a measure of the activities and technologies chosen to be included in an alliance. These chosen activities and technologies are then specified in a contract but they also influence the contract structure by defining the bargaining terms for specific rights, obligations and financial payments. The greater the scope of an alliance is in either dimension, the more interdependent and extensive the alliance and the underlying relationship is expected to be. As a result, an increase in either the *depth* or *breadth* of an alliance will increase the expected collaborative intricacy of the relationship and thus potentially alliance and contractual complexity.[4]

In the extant literature the concepts of complexity and uncertainty are often used interchangeably. This creates problems in the empirical examination of the effects of uncertainty on the governance modes of transactional relationships (Slater and Spencer, 2000).[5] In our analysis, we specifically examine how technology characteristics, which define the level of technological uncertainty in an R&D agreement, affect the *breadth* of alliance scope and thus contractual complexity. In collaborative R&D alliances, contract specification is difficult since technological know-how is highly tacit (Mowery and Rosenberg,

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[2] Theoretical conceptualization of technology scope (Khanna, 1998 and Khanna *et al.*, 1998) and empirical analysis by Oxley and Sampson (2004) acknowledge that alliance scope is a multidimensional measure but to our knowledge this is the first empirical paper to construct such a multidimensional measure.

[3] In Oxley and Sampson (2004) and Lin *et al.* (2008) functional scope is also a "vertical" measure and "horizontal" activities, which they do not include in their analysis, are related to uncertainty and complexity of the alliance project. We define technology scope, which is related to the technological complexity of a project, as a breadth or a horizontal measure.

[4] Under this treatment it is possible that a complex alliance given its high technological or functional scope, may have a contract with no or few contractual safeguards, due to established trust from prior interactions with partners. Thus, we include trust and other aspects of relational governance in our analysis and control for its impact.

[5] The treatment of uncertainty in empirical research is not consistent for other reasons as well. Most importantly, there are many different types of uncertainty. Primary uncertainty is about the lack of knowledge about the state of nature and it includes some constructs of environmental uncertainty such as regulatory changes and technological uncertainty. Secondary uncertainty is about the lack of understanding of other economic agents and generally arises from lack of communication or the inability to assess other party's plans and actions. Behavioral uncertainty, as defined by (Williamson (1975, 1981), arises from strategic actions of contracting parties such as deliberate non-disclosure or purposeful misrepresentation. Another explanation for the ambiguity in empirical examination of uncertainty is that the TCE prediction of more hierarchical governance under uncertainty only holds when relationship specific investment or asset specificity is present in a contractual relationship (Klein, 1980). Since our analysis includes R&D alliances, we contend that relationship specific investment is present in every contractual agreement in our dataset. In addition, we are very careful in defining technological complexity and technological uncertainty in our analysis.

1989). For newer and less known technologies, contract specification is expected to be even more challenging than those alliances with older, more established technologies since the level of tacitness in technological know-how is greater (Davidson and McFetridge, 1984). To mitigate potential risk, facilitate R&D collaboration and increase the effectiveness of technological communication, partner companies may choose to technologically broaden the scope of an alliance to include other related technologies, in addition to the novel technology. Thus, we hypothesize:

> *Hypothesis 1(a): Firms that engage in alliances using newer technologies will increase the breadth or the technological detail of their contracts.*
>
> *Hypothesis 1(b): Similarly, those technologies that are less prevalent will increase the breadth or the technologically detail of their contracts.*

Despite the fact that provisions related to downstream value chain activities, such as manufacturing and marketing, have the potential to be found in any contract, their presence in relationships with more technologically uncertain projects is often questionable since contract specification is difficult and details of downstream activities may not be obvious at the time the contract is signed. As a result, their presence in more technologically uncertain agreements becomes less important and it may make the agreements more complex. There is, of course, a potential tension between parties. The financing firm (if they have the downstream assets already in place) may want to negotiate these provisions at the earliest possible stage. On the other hand, the R&D firm may want to delay that negotiation as long as possible. From a valuation perspective, as time passes and more uncertainty is removed from the underlying research the more valuable it becomes. Furthermore, as we discuss below, contracting is not a costless activity; there is a cost or possible tradeoff for engaging in more complex agreements. As such firms, interested in maximizing profits, will try to minimize contracting costs. Thus, continuing with our discussion above and within the context of functional scope, we hypothesize:

> *Hypothesis 1(c): Firms that engage in alliances using newer technologies will decrease the functional depth of their contracts, i.e., they will not specify the details of downstream activities.*

Hypothesis 1(d): Similarly, firms that engage in alliances with those technologies that are less prevalent will decrease the functional depth of their contracts, i.e., they will not specify the details of downstream activities.

While the age and prevalence of the underlying technology matters, the stage of development for the focal project at the time of signing is also important in determining the complexity of the relationship. Prior research has shown that when a contract is signed has implications for the relative bargaining position of the firm and for the types of activities that are included in the contract (Higgins, 2007a). For example, earlier stage projects that are less developed are more likely to be tied to a larger number of technologies. Over time as projects mature technologies become better specified. Likewise, for later stage projects we would expect firms to focus on downstream activities (Adegbesan and Higgins, 2007). Within the context of the pharmaceutical industry, for example, Chan *et al* (2007) find that due to downstream co-specialized assets firms lock themselves into specific therapeutic categories. This leads them to engage in alliances and/or acquisitions to fill their pipelines. Given that these firms have the downstream assets already in place we would expect these firms to place a higher level of importance on the functional scope of a contract, especially when dealing with more mature research projects.

As argued above, although provisions relating to downstream activities are often found in many contracts, including earlier stage projects, their presence can be questionable since contracts are often re-negotiated at a later stages (Lerner *et al*, 2003) or the firm is subsequently purchased by their research partner (Higgins and Rodriguez, 2006). The presence of these provisions in earlier stage agreements is potentially less important and these more complex agreements are also likely to be more costly. Thus, we consider the influence stage of development in our analysis and we hypothesize:

Hypothesis 2(a): Firms that engage in earlier stage alliances will increase the technological breadth of their collaboration.

Hypothesis 2(b): Firms that engage in later stage alliances will increase the functional depth of their collaboration.

Finally, there is a complementary literature that deals with relational norms, such as trust, that views these activities as substitutes for complex contractual agreements (Granovetter, 1985; Bernheim and Whinston, 1998; Bradach and Eccles, 1989; Dyer and Singh, 1998; Gulati, 1995; Uzzi, 1997; Adler,

2001) and also as potential compliments to complex contractual agreements (Poppo and Zenger, 2002).[6] In research intensive industries where there is extensive inter-relationships and high volume of alliances firms build a reputation for being a certain type of agent. Reputation is important when other solutions to incentive problems are difficult to implement (Klein and Leffler, 1981). Moreover, under our definition of complexity, unlike other studies, it is possible that a complex alliance, i.e. an alliance with high technological or functional scope, may have a contract with no or few contractual safeguards. This may be due to established trust from prior interactions between partners if relational norms are viewed as substitutes. Thus, we include the potential impact of relational governance in our analysis, and hypothesize:

> *Hypothesis 3(a): Partners that have prior relationships with each other will, on average, enter into less complex agreements.*
>
> *Hypothesis 3(b): There is a negative relationship between a firm's stock of alliances and the complexity of their agreements.*

2.2 Allocation of control rights and value appropriation

There is a companion stream of research that focuses not on how complex a contract may be but rather *how* the underlying control rights are allocated between firms. This literature has its roots in Coase (1937) and more recently the work of Grossman and Hart (1986) and Hart and Moore (1988). Aghion and Tirole (1994) utilized this framework and theorized that the optimal ownership of a project should be assigned to the party with the greatest marginal ability to impact the final outcome, in their case the smaller, research-intensive firm. More recently these theoretical prescriptions have been empirically tested (e.g, Lerner and Merges, 1998; Lerner *et al*., 2003; Elfenbein and Lerner, 2003; Häussler, 2006; Higgins, 2007a; and, Adegbesan and Higgins, 2007).

The relationship between complexity, however defined, and the allocation of control rights has not been addressed in the literature. Contracting is not a costless activity and the interplay will also tell us the cost or tradeoff firms incur for entering these more complex relationships. Prior research focusing on

[6] In contrast to this literature, Ryall and Sampson (2006) find that contracts are more detailed when firms have prior relationships.

contract lengths (Robinson and Stuart, 2007), the degree of customization (Poppo and Zenger, 2002) or the inclusion of specific provisions (Barthelemy and Quelin, 2006) say more about the monetary cost of contracting (e.g., legal costs) and less about how all the rights attached to these contract provisions are allocated. The mere presence of provisions is not the full story. For example, a contract between parties A and B might be extensive however, the underlying allocation of rights and as a result value appropriation might be split exactly evenly. In this case, the cost of entering this complex relationship is simply the legal fees for drafting the complex agreement. In contrast, if the same contract was drafted but more rights were allocated to party A, then the true cost of contracting is the sum of the legal fees plus the additional value that has been appropriated by party A. In the eyes of the extant literature, since both contracts are of the same length and contain the same provisions, they would be viewed equally. However, if the value of the appropriated rights exceeds the cost of the complex contract then there is a net benefit to firm A. At a minimum, any potential deterrence due to transaction costs of entering a more complex agreement are diminished.

Newer and less prevalent technologies can be viewed as more risky. This uncertainty can affect the complexity of the contract, as was hypothesized above, but it can also effect the allocation of rights. A simple risk-reward view suggests that financing firms will require a higher return for investing in more risky or uncertain ventures (Higgins, 2007b). This return can come in several ways. For example, the financing firm can provide a discounted or smaller initial investment or they can extract value through appropriating additional rights. As technologies become more prevalent financing firms won't be able to "charge" this additional risk premium. As such, we hypothesize:

> *Hypothesis 4a: There is a negative relationship between the age of the technology and the allocation of rights that the financing firm receives.*
>
> *Hypothesis 4b: There is a negative relationship between the prevalence of the technology and the allocation of rights that the financing firm receives.*

We know from Higgins (2007a), Adegbesan and Higgins (2007), Häussler, 2006 and Elfenbein and Lerner (2003) that relative bargaining position matters. The stage of development of the underlying product can serve to dramatically shift the bargaining position of the firms. Later stage products have a

much higher probability of reaching market and their commercial vale is more easily determined. Research intensive firms in this position often have more than one firm they can engage in an alliance with, something that might not be otherwise available to them if the product was earlier-stage. As a result, we hypothesize:

> *Hypothesis 5: Phase or the stage of development of the focal product will be negatively related to the allocation of rights that the financing firm receives.*

Finally, the use of control rights can be used to help mitigate moral hazard issues inherent in contracts (Lerner and Malemendier, 2003; Jensen and Thursby, 2001). This is consistent with the transaction cost view on the inclusion of safeguard provisions in contracts. Regardless of how complexity is defined and analyzed moral hazard concerns remain present. For example, research intensive firms often have a clear informational advantage over the financing firms with respect to the quality of the projects they bring to the alliance market. As a result, the financing firm may offer less to guard against a "lemons problem" (Akerlof, 1970). In the alternative, financing firms may use certain contractual provisions (Lerner and Malmendier, 2003) to protect their core technologies (Khanna, 1998; Oxley and Sampson, 2004) or to provide an incentive to scientists (Jensen and Thursby, 2001). In addition to alleviating potential moral hazard problems inherent in these highly uncertain environments, the financing firm may use these provisions as bargaining devices for more control rights (Higgins, 2007a). As such, we hypothesize:

> *Hypothesis 6(a): There is a positive relationship between complexity of an alliance and the presence of financial "safeguards" (e.g., milestones and royalties) in the contract.*

> *Hypothesis 6(b): There is a positive relationship between the provision of financial "safeguards" in the contract and the allocation of control rights that the financing firm receives.*

3.0 Data and sample

We choose as our research setting the biopharmaceutical industry from 1991 to 2000 and we analyze actual alliance agreements between biotechnology and pharmaceutical firms. Alliance activity in the industry has increased dramatically over the past 20 years. It is also one of the only industries where fine grain enough data are available to conduct this type of analysis. Contracts were provided by

Recombinant Capital, a California-based biotechnology consulting firm, now a division of Deloitte. Additional data for this paper is drawn from multiple sources including BioScan, FDA Orange Book, IMS Health, Thomson Derwent, NDA Pipeline, Pharmaprojects and Compustat. Variables are described below and descriptive statistics and correlations are presented in Table 1 and Table 2, respectively.

3.1 Dependent Variables

***Contractual complexity*.** Fig. 1 presents our notion of contractual complexity in a 2 x 2 matrix. We further divide functional and technological scope into *low* and *high* types. Technological scope is deemed *low* if the alliance agreement focuses on only one technology. In contrast, technological scope is deemed *high* if the alliance agreement focuses on more than one technology. Obviously, the larger number of technologies covered, the greater the internal capabilities of the two firms need to be – especially for the biotechnology firm. We define *Technological scope* as a dummy variable that equals one if the alliance contract covers more than one technology. Thirty-three percent of the sample contracts fit in the *high* category.

Functional scope is deemed to be *low* if the alliance agreement focuses solely on research and development. In contrast, functional scope is deemed to be *high* if the alliance agreement specifies provisions dealing with marketing and manufacturing. We therefore define *Functional scope* as a dummy variable that equals one if an alliance contract specifies marketing or manufacturing provisions. Thirty percent of the sample contracts fit in the *high* category.

Referring to Fig.1, an alliance contract in the top left quadrant (L, L) is one that focuses only on one technology and contains no provisions with respect to marketing or manufacturing. In contrast, an alliance contract in the lower right quadrant (H, H) is one that focuses on more than one technology and contains provisions for marketing or manufacturing. For the overall sample, 42 percent of the alliance contracts fall into the (L, L) quadrant, 25 percent fall into the (H, L) quadrant; 28 percent fall into the (L, H) quadrant and 5 percent fall into the (H, H) quadrant.

We combine these two dimensions to construct a continuum for measuring overall contract complexity. We categorize contracts in the following order from simple to complex: (L, L), (H, L), (L,

H), and (H, H). That is we define the simplest contract (L, L) as one that does not include marketing, or manufacturing provisions (*Functional scope* equals "L") and covers only one technology (*Technological scope* equals "L"). In contrast, we define the most complex contract (H, H) as one that includes marketing or manufacturing (*Functional scope* equals "H") and covers more than one technology (*Technological scope* equal "H").

By reformatting the quadrants represented in Fig. 1 into a linear continuum we need to decide whether to order (H, L) and (L, H) in this manner or (L, H) and (H, L). After consulting with representatives responsible for negotiating alliance contracts from both the pharmaceutical and biotechnology industry, we use the former, (H, L) and (L, H). There was general agreement that alliances covering more than one underlying technology made the overall alliance more complex than an expanded functional scope. We define *Complex* as a categorical variable from one to four covering our four categories of contractual complexity. (L, L) is assigned one while (H, H) is assigned a value of four. *Complex* has a mean (median) value of 1.96 (2.00) and a standard deviation of 0.95.

Alliances and determination of control rights. Alliance contracts are obtained from Recombinant Capital's RDNA database. We randomly selected 240 alliances involving just two parties (a pharmaceutical and biotechnology firm), whose main focus is on research and development and has a detailed contract analysis available. We restrict our sample to alliances involving just two firms in order to be able to clearly identify the allocation of control rights. Consistent with Lerner *et al* (2003) and Higgins (2007a) and in order to avoid unnecessary heterogeneity, transactions are excluded where: (1) one of the parties is a government agency or university; (2) the current alliance is a renegotiation or restatement of a previous alliance between the two firms; (3) there exists no research component or aspect to the alliance; or, (4) one firm has a controlling interest in the other firm (greater than 50%).

Each contract is reviewed for relevant deal information including: the date of the alliance, the technology and subject covered, total value of the agreement (*Size*), the presence of a royalty (*Royalty*), the presence of milestones (*Milestone*), and stage of the lead product. Contracts are also reviewed in order to determine the allocation of control rights. After consulting with private lawyers, corporate

counsel and other professionals in the biotechnology and pharmaceutical industries, the following bundle of eight control rights are selected to be included.[7] We define *Total rights* as the number of rights that are allocated to the pharmaceutical (financing) firm.

Intellectual Property Rights
1. Ownership of patents
2. Control and responsibility for patent litigation process
3. Transfer of unpatented R&D "know-how"

Licensing Rights
4. Right to sub-license
5. Royalty payment tie-ins

Exit Rights
6. Product reversion rights upon termination
7. Changes in control
8. Right to terminate without cause

3.2 Independent Variables

Technology age and prevalence. Age is determined by when a focal technology is first identified in any alliance.[8] It is certainly the case that focal technologies may exist before their first appearance in an alliance; however, in most cases detecting this type of information in a consistent manner is not possible. By focusing on the appearance of a technology in a first alliance we are using a homogenous standard across all technologies. We define *Technology age* as a dummy variable that equals one if the difference between the year of the contract and year of first appearance in the population of alliances for the focal technology is less than or equal to five years.[9] The mean value for *Technology age* is 0.22 which implies that 22 percent of the focal technologies are less than or equal to five years of age.

Just because a technology is old does not necessarily imply that it is prevalent or has diffused into the industry. We attempt to capture how prevalent a focal technology is by counting the number of other alliances that used the focal technology until the date of the sample alliance. As such, we define

[7] The rights analyzed in this paper are slightly different than the rights considered in Lerner *et al* (2003), Higgins (2007) and Adegbesan and Higgins (2007a). The differences in rights selection across these projects mainly revolves around the issues being studied. Our specific selection of rights generally follows Higgins (2007) and as a robustness check we use the more broad selection of rights considered by Lerner *et al* (2003). Our results remain qualitatively consistent with these alternative measures.

[8] We limit the lower end of age at 1980. This constraint is imposed due to data limitations.

[9] As a robustness check we define a variable *Max Years Since*, to be the difference between the year of the contract and the year of the first alliance in the population of alliances for the focal technology. Results were qualitatively consistent. The mean (median) age of our focal technologies are 10.20 (9) years with a standard deviation of 4.96.

Technology count as the number of alliances in the population of Recombinant Capital's database within the focal technology that have been initiated until the sample alliance. The mean (median) number of prior alliances in the population utilizing the same sample focal technology is 214.34 (120). The simple correlation between *Technology count* and *Max Years Since* is 0.5483. This suggests that while there is a positive correlation, simple age is not the only driving factor of a technology's prevalence.

Phase. We use ReCap, NDA Pipeline and Pharmaprojects to identify the stage of the development of the focal project with a dummy variable, *Phase*, which equals 1 if the lead product is in Phase II or III clinical testing. Projects in later phases of development are more mature and likely to include more downstream activities. Only 22 percent of our sample has lead projects in Phases II or III of clinical testing at the initiation of the alliance.

Prior Relationships. To examine the importance of prior relationships (Poppo and Zenger, 2002; Gulati and Nickerson, 2007) we use two variables: *Stock*, defined as the total number of prior alliances by the pharmaceutical (financing) firm until the year before the focal alliance and a dummy variable, *Prior*, which equals one if the two parties had a prior alliance in the past five years. The mean alliance stock is 122 with a median of 88 and 24 of the alliances occurred between parties with a prior relationship

Control variables. Prior research has demonstrated that relative bargaining position matters (Elfenbein and Lerner, 2003; Häussler, 2006; Higgins, 2007a). As such, we construct several measures of relative bargaining position. First, we follow Higgins and Rodriguez (2006) and Higgins (2007a) and construct a weighted-value of each pharmaceutical firm's pipeline products, *Score,* using data from NDA Pipeline, Pharmaprojects and supplemented from ReCap. A relatively high *Score* indicates a healthy product pipeline versus a company with a lower value *Score*. Firms with a high *Score* negotiate and bargain from a position of relative strength (Higgins, 2007a). Second, we control for the availability of public financing (Lerner *et al*., 2003) by including the amount of money raised by biotechnology firms in the year prior to an alliance, *BioIPO*. Third, we control for the general availability of corporate funding in the year prior to an alliance, *Payout* (Higgins, 2007a). We define *Payout* as the ratio of external pharmaceutical R&D alliance financing divided by internal R&D expenditures. This provides us with a

measure of how much the industry is committing to external research. Finally, we create a dummy, *First alliance*, that equals one if it is the first alliance for the biotechnology company.

We define three variables to control for potential size and capability effects: *Intensity* is the ratio of pharmaceutical R&D expenditures to sales; *PMarket* is the market capitalization of the pharmaceutical firm; and, *BEmp*, is the total number of employees at the biotechnology firm. We use total employees instead of market capitalization because we are able to obtain employee data for private firms from Bioscan. All financial data are in constant 1999 dollars.

4.0 Empirical findings

4.1 Determinants of technological and functional scope

4.1.1 Technology prevalence and age

We first investigate the effects technology age and prevalence have on technological and functional scope of contracts in Table 3. Models 1-4 presents probit estimates regressing *Technology scope* on a series of independent variables expected to affect the probability that a pharmaceutical firm enters a technologically complex agreement while Models 5-8 present probit estimate regressing *Functional scope* on the same set of independent variables. Year fixed effects and cluster standard errors were used in all specifications. Results are robust to logit estimation.

Across Model 1-Model 4 *Technology age* is positive with coefficients ranging from 1.09 to 1.18 with corresponding marginal effects ranging from 0.40 to 0.45, all significant at the 1 percent level. Consistent with *Hypothesis 1(a)*, newer technologies appear to be coupled together or combined with other technologies. *Technology count* has the expected negative coefficient in all models (Model 1-Model 4). Coefficients range from -0.06 to -0.08 with corresponding marginal effects ranging from -0.01 to -0.03, significant at least at the 5 percent level. Supporting *Hypothesis 1(b)*, alliances that focus on technologies that are less prevalent in the population of alliances are more likely to be coupled with another technology. Combined, these two findings suggest that an alliance contract will have a greater *breadth* as a way to mitigate possible risk when technological uncertainty is expected to be higher.

Across Model 5-Model 8 *Technology age* is negative with coefficients ranging from -0.80 to -1.13 with corresponding marginal effects ranging from -0.21 to -0.26, all and significant at the 1 percent level. As these technologies are newer, it makes less sense for companies to negotiate marketing and/or manufacturing provisions. The results on *Technology count* bolster this finding with coefficients ranging from -0.13 to -0.21 and corresponding marginal effects ranging from -0.03 to -0.07, significant at the 1 percent level. The negative coefficient implies that technologies that are less prevalently utilized in the population of alliances are more likely to be functionally narrow. These results strongly support *Hypotheses 1(c) and 1(d)*. Taken together this suggests that biotechnology firms have had some success in delaying the negotiation of these contractual terms. Recent work by Wakeman (2008) hints at why biotechnology firms may want to delay these negotiations. His work focuses on the desire of biotechnology firms to maintain co-promotion rights. As a result, biotechnology firms, desiring these rights, may attempt to postpone the negotiation of these provisions until such time they are in a better bargaining position.

4.1.2 Phase or stage of development

Agreements signed where the focal product is in late-stage clinical testing (defined as either Phase II or Phase III) are less likely to be associated with technologically broad contracts. In Model 1-Model 4 coefficients on *Phase* range from -1.12 to -1.64 with marginal effects ranging from -0.30 to -0.37, significant at the 1 percent level. This result is consistent with *Hypothesis 2(a)*. By the time a drug candidate moves into late-stage clinical testing it is more focused and refined – risk has also dramatically declined.

By far the most important factor influencing the functional scope of a contract is the stage of the focal product. In Model 5-Model 8 coefficients on *Phase* range from 1.07 to 1.23 with corresponding marginal effects ranging from 0.36 to 0.44, significant at the 1 percent level. This finding supports *Hypothesis 2(b)* and is not unexpected since focal products in later stages of clinical testing have a higher probability that they will reach FDA approval. As a result, marketing and manufacturing become more

relevant, especially if the pharmaceutical (financing) firm already has downstream co-specialized assets in place (Chan *et al*., 2007).

4.2 Contractual complexity

We combine our two measures of contractual complexity and define *Complex* as a categorical variable ranging from one to four. Each of these values corresponds to one of the four quadrants from Fig. 1 representing an ever increasing complex contract. We present ordered probit results in Table 4 analyzing the effects of our three main areas of interest: relational norms, technology age and prevalence and phase or stage of development. Year fixed effects and cluster standard errors were used in all specifications. Results remain robust to ordered logit specifications.

4.2.1 Relational norms

Across all models tested in Table 4 we find a negative and significant (at the 1 percent level) relationship between *Prior* and contractual complexity. Contracts between firms that have prior relationships tend to be less complex. This supports *Hypothesis 3(a)* and is consistent with previous findings that argue this trade-off is based on some level of trust between the firms (Granovetter, 1985; Bernheim and Whinston, 1998; Bradach and Eccles, 1989; Dyer and Singh, 1998; Gulati, 1995; Uzzi, 1997; Adler, 2001; Poppo and Zenger, 2002). We also find a negative and significant (at the 5 percent level) relationship between *Stock* and contractual complexity, providing support for *Hypothesis 3(b)*. We believe this finding relates to a firm's reputation and possible may hint at an underlying preference for less complex agreements.

Given our research setting coupled with the long research cycles experienced in the industry, high risk and potential significant pay-offs, we interpret these findings along the lines of Poppo and Zenger (2002). In contrast to some of the relational norms literature that views these as substitutes they view trust and complexity as a complement. Trust is not acting to replace the codification of terms but rather may be creating a setting where a series of contracts can be entered over a long development cycle.

4.2.2 Technology age, prevalence and stage of development

Overall, the younger and less prevalent a technology is the more complex the underlying agreement will be. This is reflected in the positive and significant coefficient on *Technology age* and the negative and significant coefficient on *Technology count*. Even controlling for prior relationships between the parties, *Prior*, and the stock of pharmaceutical alliances, *Stock*, these direct effects remain relevant. In addition, *Phase* is negative and significant suggesting that focal products in later stages of clinical testing tend to have less complex agreements. These findings are consistent with the results we discussed above.

4.3 Allocation of control rights

Consistent with previous work (Lerner and Merges, 1998; Lerner *et al*, 2003; Lerner and Malmendier, 2004; Adegbesan and Higgins, 2007; Higgins, 2007a), we use the total number of control rights allocated to the pharmaceutical firm, *Total rights*, as the dependent variable in Table 5. Given the nature of the dependent variable we test for overdispersion in the data to determine whether a Poisson or negative binomial model is warranted. We test for overdispersion utilizing a likelihood ratio test based on the Poisson and negative binomial distributions (Cameron and Trivedi, 1998). This is to test the equality of the mean and the variance imposed by the Poisson distribution against the alternative that the variance exceeds the mean. We reject the null hypothesis and as a result we present results utilizing a negative binomial model.[10] Year fixed effects and cluster standard errors are used in all specifications.

4.3.1 Technology age and prevalence

After controlling for our various measures of relative bargaining position and size of the partner firms, the coefficients on *Technology age* are positive and significant, providing support for *Hypothesis 4(a)*. Recall that *Technology age* is defined as a dummy that equals one if the difference between the year of the alliance contract and year of first alliance in the population, for that focal technology, is less than or equal to 5 years. As a result, the positive coefficient on *Technology age*, in this regression should be interpreted that younger technologies will lead to more rights being allocated to the pharmaceutical

[10] Just to compare the potential effects of the overdispersion in the data we re-ran the regressions in Table 5 with a Poisson model. The results remained qualitatively consistent.

(financing) firm. Coupled with our prior findings on complexity, younger technologies appear to lead to more complex agreements that lead to more rights being appropriated or allocated to the pharmaceutical (financing) firm. This result is consistent with a simple risk-reward point of view. Newer technologies are, in general, more risky or uncertain and as a result larger rewards (or more rights) need to be offered to entice a firm to make the investment.

Unfortunately, across all specifications, we find no relationship between *Technology count* and the allocation of rights. While the coefficients are all positive, none are significant at standard levels. As a result, we do not find support for *Hypothesis 4(b)*.

4.3.2 Phase or stage of development

Across all specifications tested the phase or stage of development, *Phase*, is negatively related to the allocation of rights that a pharmaceutical firm receives. This finding supports *Hypothesis 5* and is consistent with Higgins (2007a). Biotechnology firms that are able to delay an alliance until their focal product is ready for later stage clinical testing place themselves in a superior bargaining position than if they engage in an alliance earlier. Risk is reduced from the underlying equation and often more than one pharmaceutical firm end up competing for an alliance. Combined with the results above, focal products in later-stages of development tend to have less complex agreements with fewer rights flowing to the pharmaceutical firm. From a transaction cost perspective, contracting costs are lower *and* value appropriation is *higher* for the biotechnology firm.

4.3.3 Relational norms

Interestingly, across all specifications tested neither of our variables that we use to proxy for relational norms, *Prior* and *Stock*, are significant at conventional levels. We know from theory (Aghion and Tirole, 1994) that rights are predicted to flow to the research-intensive (biotechnology) firm. However, the extant empirical literature finds an allocation of rights that tend to predominately flow to

the financing (pharmaceutical) firm, in contrast to theory.[11] The relational norms literature demonstrates that contracts can become less complex as a result of prior contacts however the underlying allocation of rights does not appear to change.[12] It appears that trust only goes so far. One explanation for not seeing a change in control rights relates to possible opportunistic behavior. Lin *et al*. (2008) argue that prior partners are more likely to understand each other's know-how, operational routines and managerial practices. As a result, they can more easily overcome more informal methods of intellectual property protection (Arrow, 1974; Heinman and Nickerson, 2002, 2004) and engage in opportunistic behavior.

4.4 Contractual safeguards

Constructing a complete contract is not feasible. It is not possible to ponder and codify every contingency that parties may face. Notwithstanding these difficulties it is possible to build safeguards into contracts in order to help mitigate potential moral hazard issues (Lerner and Malemendier, 2003), guard against the classic "lemons" problem (Akerlof, 1970) and provide an incentive to scientists (Jensen and Thursby, 2001). One contractual mechanism utilized is milestone payments. These payments can be clearly codified around a verifiable goal thereby preventing firms from committing the full amount of resources up-front. Another mechanism utilized is back-end royalty payments.

We test the relationship of both these mechanisms, *Milestone* and *Royalty*, on contractual complexity in Table 4. Coefficients on *Milestone* are positive and significant across all specifications tested. However, the coefficients on *Royalty* are not significant at any standard level. As a result *Hypothesis 6(a)* is only supported in part. The presence of milestones in more complex agreements makes sense, especially given the discussion in the previous paragraph. The lack of a finding on royalties, in our view, may just simply suggest that the issues of incentivizing scientists (Jensen and

[11] A recent paper by Goldfarb *et al.* (2008) focusing on angel investors demonstrates an allocation of rights between the financing firm (angel investor) and research-intensive firm (very early stage start-ups) that is consistent with theory.

[12] The average number of rights allocated to the pharmaceutical firm, across our sample, exceeds 50% (Table 1). This is consistent with the extant literature that shows a greater proportion of rights being allocated to the financing firm.

Thursby, 2001) are more universal in nature and not limited to those situations where contracts are more complex.[13]

Next, we test whether the presence of either of these contractual safeguards have any impact on the underlying allocation of rights between the parties. Results are reported in Table 5. Although the coefficient on *Milestone* is positive, it is not significant at any standard level. The coefficients on *Royalty* are positive, ranging from 0.17 to 0.22, and significant at the 1 percent level across all specifications tested. Combined these results, once again, provide partial support for *Hypothesis 6(b)*. The results on *Royalty* seem to suggest that pharmaceutical firms are able to "pay" for additional control rights through the inclusion of royalty payments in the contracts. This seemingly is a win-win for pharmaceutical firms since they not only obtain additional rights but also royalties that serve to incentivize the scientists and defer monetary commitments in this highly uncertain environment. It is puzzling why biotechnology firms would accept downstream royalty payments versus negotiating for larger up-front or milestone payments. The risk of failure in this field is high and the probability a product will make it to market is low. Moreover, Higgins and Rodriguez (2006) show that pharmaceutical firms, when they acquire smaller biotechnology firms, tend to acquire ones for which they had a prior research relationship. In these cases, the pharmaceutical firms avoid having to pay the downstream royalties. Biotechnology firms, on the other hand, effectively gave up value for a downstream payment with little chance of coming to fruition.[14]

5.0 Conclusion

In this paper we have attempted to further understand the nature of alliances and how their contract structures and allocation of rights can impact a firm. The literature tends to view alliances as a black-box. Unfortunately, just having a portfolio of alliances tells us little about *how* a firm may benefit

[13] This lack of finding may also be attributed to the quality of the data. While we are able to determine the *presence* of a royalty payment (they are present in 44 percent of our contracts) we are not able to determine the *rate* of the royalty. For the most part this is confidential data and not available. It may be that case that the *royalty rate* is the appropriate variable to consider versus just their mere presence. This was just not possible with available data.

[14] With these *ex post* contracts it is not possible to determine what exactly the biotechnology firms gave up in exchange for the downstream royalties.

from these activities. Clearly, this is an issue critical to managers – especially those that are charged with building these portfolios. In order to understand these issues we create a multi-dimensional framework in which to analyze several determinants that drive complexity. This, however, is just one part of the equation. We then take the next step to see if these determinants have any impact on how value is split between firms. By conducting this additional analysis we are able to look at a more holistic cost/benefit of engaging in these agreements. If, for example, a determinant tends to make a contract more complex, there is a cost to the firm. However, if as a result of spending the resources and time to enter a more complex agreement additional value is appropriated in terms of the underlying rights (such that the benefit exceeds the cost) then this was an appropriate decision by the firm. On the other hand, if a determinant not only makes an agreement more complex but also gives up value then this is sub-optimal decision.

In Fig.2 we demonstrate the inter-play between alliance complexity and control rights and attempt to determine the net effect on the firm. *Technology age*, i.e. the newness of technology increased the complexity of an agreement thereby increasing transaction costs. It was also positively related to the allocation of rights that a pharmaceutical firm received. If this value that was appropriated through control rights exceeds the cost of entering the more complex agreement, then this should be viewed as a net benefit to the firm. *Phase* decreased the complexity of an agreement (i.e., lower costs) but it was also negatively related to the number of rights a pharmaceutical firm received. Hence, if the value lost in rights exceeded the savings from lower contracting costs, this would be a net loss to the firm. This type of ad hoc analysis isn't possible for *Technology count* (prevalence), *Prior*, *Milestones*, and *Royalties* since one of the two components (complexity or control rights) were not able to be determined. Notwithstanding this limitation, the same thought process is appropriate in trying to look at the net effects of entering a more/less complex contract and looking at how rights (value) are allocated (appropriated).

Overall, our results extend the contractual complexity literature while making a first attempt to bridge it together with the control rights literature. First, we extend the literature on contractual complexity by modeling complexity in a multi-dimensional framework. This framework allows us to

focus on both the functional scope and technological scope of an agreement. Second, we take our framework and analyze the determinants that increase the probability an alliance agreement will be more complex. Third, we tie these same determinants of contractual complexity to the control rights literature by analyzing the relationship between contract structure and rights allocation. Finally, we contribute to the literature on relational norms. Prior relationships and issues of trust are important in contracting. Our findings suggest that, consistent with prior literature, prior relationships tend to make contracts less complex. However, there is no effect on the allocation of rights. Trust, appears, only to go so far.

No research is without limitations. We know from previous work that strategic alliances create shareholder value (Higgins, 2007a; Chan *et al*, 1997; McConnell and Nantell, 1995). A logical next step for this research will be to address the question of the impact firm performance and shareholder value. These effects could then be tied nicely back into the net effects we attempted to describe in Fig. 2. We, however, leave this task for future work.

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Table 1: Descriptive Statistics

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
Score	168.91	124.40	156.43	11.60	824.40
Functional scope (%)	0.30			0.00	1.00
Technological scope (%)	0.33			0.00	1.00
Total rights	4.55	4.01	1.57	0.00	8.00
Complex	1.96	2.00	0.95	1.00	4.00
PMarket ($)	49570.51	37519.00	45191.26	99.57	216049.00
BEmp	0.470	0.137	2.24	0.002	28.10
Intensity	0.19	0.11	0.68	0.003	10.21
First alliance (%)	0.06			0.00	1.00
BioIPO ($)	4673.22	4200.00	2055.05	900.00	8500.00
Payout (%)	0.08	0.04	0.11	0.00	0.47
Size ($)	57.64	37.50	81.41	0.50	815.00
Phase (%)	0.22			0.00	1.00
Technology age	0.22			0.00	1.00
Technology count	214.34	120.00	221.90	0.00	881.00
Alliance stock	121.87	88.00	113.60	1.00	551.00
Prior	0.24			0.00	1.00
Milestone (%)	0.54			0.00	1.00
Royalty (%)	0.44			0.00	1.00
Max Years Since	10.20	9.00	4.96	1.00	21.00

Table 2: Correlation Matrix

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Score	1.0000																	
2. Functional scope	-0.0095	1.0000																
3. Total rights	0.1859	-0.1590	1.0000															
4. Complex	-0.0292	0.2768	0.0745	1.0000														
5. Intensity	0.0548	-0.0546	0.0950	0.1010	1.0000													
6. Pmarket	0.4341	0.0252	0.0651	-0.0681	-0.1190	1.0000												
7. Bemp	0.1151	-0.0330	-0.1460	0.0378	0.0254	-0.0194	1.0000											
8. Prior	-0.1325	0.1883	-0.1704	0.1074	-0.0364	-0.0833	-0.0253	1.0000										
9. First alliance	-0.1020	0.0871	0.0108	0.1143	0.0068	-0.0098	-0.3117	0.1277	1.0000									
10. BioIPO	0.2437	0.0057	-0.0217	-0.0474	-0.0476	0.3978	0.0182	-0.0106	0.0221	1.0000								
11. Payout	0.1044	0.0877	0.0126	0.1661	-0.0049	0.2033	0.0453	-0.0469	-0.0551	0.0543	1.0000							
12.Size	0.2036	0.2509	0.0034	0.1640	-0.0048	0.2364	0.1121	0.3982	-0.0012	0.2539	0.1162	1.0000						
13. Phase	-0.0539	0.3777	-0.2330	-0.1515	-0.1506	0.0598	0.0464	0.1210	-0.0538	0.0389	-0.0772	0.2386	1.0000					
14. Technology age	-0.2061	-0.1866	0.1004	0.2769	-0.0266	-0.1350	-0.0369	-0.0155	0.0788	-0.2419	0.2265	-0.0734	-0.2928	1.0000				
15. Technology count	0.1736	-0.1702	-0.0174	-0.1334	-0.0548	0.0607	0.1075	0.0574	0.0117	0.1028	0.0589	0.2095	-0.0135	-0.0804	1.0000			
16. Alliance stock	0.2141	-0.1674	-0.0489	-0.0526	0.0799	0.0127	0.6363	-0.0843	-0.5702	0.1529	-0.0494	0.0773	0.0405	-0.1580	-0.0213	1.0000		
17. Milestone	0.0573	0.2661	0.1911	0.2151	-0.0040	0.0381	-0.0491	0.0931	0.0327	0.0616	0.0794	0.3124	0.2072	-0.0498	0.0930	-0.0196	1.0000	
18. Royalty	-0.0587	0.2101	-0.0664	0.1010	-0.1641	-0.0856	-0.0608	-0.0027	0.0720	-0.1249	0.0357	-0.0102	0.1138	0.1004	-0.0308	-0.1778	0.3241	1.0000

Table 3: The Determinants of Technological and Functional Scope

	Technological Scope				Functional Scope			
	Model 1	Model2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Technology age	**1.0962**[a]		**1.1851**[a]	**1.1146**[a]	**-0.8053**[a]		**-0.9965**[a]	**-1.1351**[a]
	(0.2183)		(0.2487)	(0.2710)	(0.3000)		(0.4175)	(0.4254)
*Technology count**		**-0.0633**[b]	**-0.0766**[a]	**-0.0858**[b]		**-0.1363**[a]	**-0.1946**[a]	**-0.2165**[a]
		(0.0333)	(0.0218)	(0.0414)		(0.0499)	(0.0535)	(0.0534)
Phase	**-1.1576**[a]	**-1.1209**[a]	**-1.6067**[a]	**-1.6224**[a]	**1.0868**[a]	**1.2365**[a]	**1.0373**[a]	**1.0793**[a]
	(0.2617)	(0.2882)	(0.4057)	(0.3926)	(0.2921)	(0.3695)	(0.3269)	(0.2908)
*Alliance stock**			0.2062	0.1698			**-0.4712**[a]	**-0.5439**[a]
			(0.1627)	(0.1624)			(0.1206)	(0.1744)
*Pmarket**	0.0678	-0.0417	0.0427	-0.0435	-0.0328	-0.0071	-0.0081	-0.0056
	(0.0821)	(0.1032)	(0.0942)	(0.1049)	(0.0722)	(0.0840)	(0.0767)	(0.0831)
*BEmp**		0.0708		0.0750		-0.0728		-0.0686
		(0.1186)		(0.1563)		(0.0841)		(0.0843)
*Score**		-0.0517	0.03047	0.0236			-0.0455	-0.0378
		(0.5744)	(0.5562)	(0.5376)			(.5790)	(0.5502)
*Intensity**	**0.2696**[b]	**0.3268**[c]	**0.1743**[c]	**0.2506**[c]	-0.0663	-0.0403	0.0493	-0.0558
	(0.1421)	(0.2020)	(0.0942)	(0.1407)	(0.0613)	(0.1323)	(0.1174)	(0.1598)
First alliance			0.8186	0.8643			0.8442	0.7613
			(0.6525)	(0.6535)			(0.5732)	(0.6859)
*BioIPO**	-0.3580			-0.4278	0.6289			0.1846
	(0.3726)			(0.4450)	(0.7249)			(0.6278)
*Payout**		0.0881		0.0827		**0.3064**[b]		**0.2718**[a]
		(0.0996)		(0.0848)		(0.0935)		(0.0975)
*Size**			**0.2016**[c]	**0.2012**[c]			**0.5573**[a]	**0.5079**[a]
			(0.1091)	(0.1130)			(0.1298)	(0.1463)
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y	Y	Y	Y
Cluster standard errors	Y	Y	Y	Y	Y	Y	Y	Y
N	234	222	234	222	234	222	234	222
Wald χ^2	196.21	240.70	175.47	269.63	82.52	72.61	134.4	203.48
Psuedo R^2	0.2207	0.2377	0.2457	0.2569	0.2081	0.2404	0.2931	0.3210

[a], [b], and [c] represent signficance at the 1, 5 and 10 percent levels, respectively

* natural logs of these values were used for these specifications

Table 4: Determinants of Contractual Complexity

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Technology age	**0.7152**[a]	**0.7102**[a]	**0.5897**[a]	**0.7567**[a]	**0.7423**[a]	**0.5954**[a]	**0.6268**[a]
	(0.1850)	(0.2217)	(0.1962)	(0.1963)	(0.2018)	(0.1931)	(0.2133)
*Technology count**		**-0.0797**[a]	**-0.1048**[a]	**-0.1162**[a]	**-0.1186**[a]	**-0.1176**[a]	**-0.1513**[a]
		(0.0335)	(0.0331)	(0.0355)	(0.0366)	(0.0344)	(0.0391)
Phase			**-0.3640**[b]	**-0.2847**[c]	**-0.2817**[c]	**-0.4479**[b]	**-0.5081**[b]
			(0.1701)	(0.1652)	(0.1656)	(0.1780)	(0.2134)
*Alliance stock**				**-0.1838**[b]	**-0.1662**[b]	**-0.1453**[b]	**-0.1395**[b]
				(0.0919)	(0.0802)	(0.0715)	(0.0667)
Prior				**-0.1726**[a]	**-0.1724**[a]	**-0.1833**[a]	**-0.1518**[a]
				(0.0575)	(0.0547)	(0.0528)	(0.0433)
Milestone				**0.7002**[a]	**0.6894**[a]	**0.4335**[a]	**0.5334**[a]
				(0.1818)	(0.1761)	(0.1749)	(0.1912)
Royalty					-0.0938	-0.0464	0.1098
					(0.1732)	(0.1659)	(0.1816)
*PMarket**	-0.0104	-0.0610	-0.0369	-0.0501	-0.0450	-0.0439	-0.0967
	(0.0554)	(0.0735)	(0.0512)	(0.0620)	(0.0595)	(0.0533)	(0.0688)
*BEmp**		0.0079		0.1229			0.1463
		(0.0823)		(0.0980)			(0.1229)
*Score**	-0.0485			0.0942	0.0054	0.0664	-0.0310
	(0.1023)			(0.0681)	(0.0781)	(0.0585)	(0.0774)
*Intensity**		**0.1636**[c]			**0.1187**[c]		0.1127
		(0.0942)			(0.0658)		(0.1160)
First alliance	0.2552		0.3674			0.3546	0.4975
	(0.2719)		(0.3137)			(0.3921)	(0.5869)
*BioIPO**	0.1437			0.0476			-0.2640
	(0.4758)			(0.4242)			(0.4191)
*Payout**		**0.1656**[c]			0.1098		**0.1497**[c]
		(0.0873)			(0.0801)		(0.0779)
*Size**			**0.3372**[a]			**0.2821**[a]	**0.2510**[a]
			(0.0761)			(0.0806)	(0.1001)
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y	Y	Y
Cluster standard errors	Y	Y	Y	Y	Y	Y	Y
N	234	222	234	222	234	234	222
Wald χ^2	40.58	91.19	79.48	72.83	78.81	72	190
Psuedo R^2	0.0753	0.0846	0.0887	0.1083	0.1125	0.1089	0.1241

[a],[b], and [c] represent signficance at the 1, 5 and 10 percent levels, respectively

* natural logs of these values were used for these specifications

Table 5: Allocation of Control Rights

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Technology age	**0.0973**[b]	**0.1042**[b]	**0.1501**[b]	**0.1288**[a]	**0.1338**[b]	**0.1401**[b]	**0.1497**[b]
	(0.0503)	(0.0521)	(0.0667)	(0.0444)	(0.0462)	(0.0704)	(0.0875)
*Technology count**		0.0055	0.0149	0.0101	0.0101	0.0064	0.0075
		(0.0122)	(0.0104)	(0.0094)	(0.0116)	(0.0112)	(0.0108)
Phase			**-0.1808**[a]	**-0.2085**[a]	**-0.1887**[a]	**-0.1887**[a]	**-0.2214**[a]
			(0.0550)	(0.0512)	(0.0543)	(0.0521)	(0.0531)
*Alliance stock**				0.0474	0.0317	0.0508	0.0052
				(0.0372)	(0.0284)	(0.3344)	(0.0360)
Prior				0.1389	0.1349	0.1156	0.1174
				(0.0921)	(0.0965)	(0.0818)	(0.0867)
Milestone			0.0760	0.0682	0.0692	0.0703	0.0654
			(0.0541)	(0.0449)	(0.0443)	(0.0500)	(0.0534)
Royalty			**0.1969**[a]	**0.2261**[a]	**0.1929**[a]	**0.1736**[a]	**0.1914**[a]
			(0.0541)	(0.0500)	(0.0511)	(0.0477)	(0.0514)
*PMarket**	0.0159	0.0140	0.0045	-0.0009		0.0121	0.0095
	(0.0151)	0.0227	(0.0181)	(0.0138)		(0.0207)	(0.0203)
*BEmp**	**-0.0548**[b]	**-0.0530**[b]				**-0.0480**[c]	**-0.0471**[c]
	(0.0223)	(0.0246)				(0.0285)	(0.0277)
*Score**		**0.0593**[c]	**0.0591**[c]	**0.0554**[c]	**0.0636**[b]	**0.0652**[b]	**0.0604**[c]
		(0.0355)	(0.0317)	(0.0299)	(0.0313)	(0.0310)	(0.0311)
*Intensity**		0.0546	0.0104		0.0103	0.0285	0.0161
		(0.0338)	(0.0337)		(0.0277)	(0.0337)	(0.0276)
First Alliance		-0.0858		-0.0749		-0.0921	-0.0288
		(0.1179)		(0.1085)		(0.1196)	(0.1371)
*BioIPO**	-0.0162		**-0.1173**[c]		-0.0485		-0.0754
	0.0878		(0.0712)		(0.0716)		(0.0639)
*Payout**		-0.0153				-0.0173	-0.0183
		(0.0248)				(0.0234)	(0.0254)
*Size**				-0.0184			0.0024
				(0.0206)			(0.0232)
Year fixed Effects	Y	Y	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y	Y	Y
Cluster standard errors	Y	Y	Y	Y	Y	Y	Y
N	222	222	234	234	234	222	222
Wald χ^2	59.77	88.80	89.34	121.19	89.71	234.10	388.64

[a, b], and [c] represent signficance at the 1, 5 and 10 percent levels, respectively

* natural logs of these values were used for these specifications

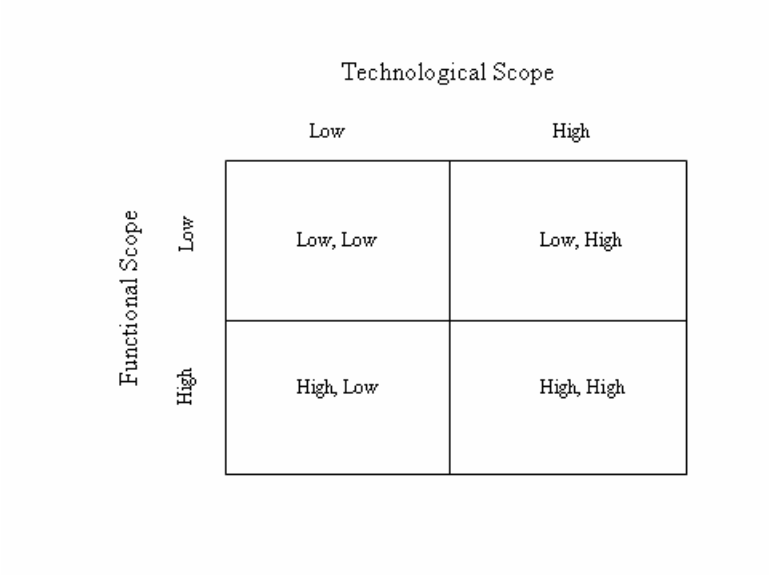

Fig 1. Presents our multi-dimensional framework for contract complexity in a two-by-two matrix. Functional scope is defined as *low* if the alliance agreement focuses solely on research and development and contains only our focal rights. Functional scope is defined as *high* if the agreements include provisions dealing with marketing, manufacturing and distribution. Technological scope is defined as *low* if the agreement focuses on one technology while it is defined as *high* if more than one technology is involved.

	A	**B**	
	Complexity	**Control Rights**	**Net Effect**
Technology Age	↑	+	+ (if B > A)
Technology Prevalence	↓	?	?
Phase/Stage of Development	↓	-	- (if B > A)
Prior Relationships	↓	?	?
Milestones	↑	?	?
Royalties	?	+	?

Fig.2. Key drivers of complexity are listed down the left side of the figure. From the perspective of the financing (pharmaceutical) firm we attempt to determine the net effect when considering the cost of entering a complex agreement coupled with the cost/benefit in terms of value appropriation (due to the allocation of control rights). For example, in the case of *Technology age*, contracts were most complex (A), i.e., more costly but the firm appropriated more rights (B). If the value that was appropriated (B) exceeds the costs due to complexity (A), then this is a net gain for the firm. If the effect was not able to be determined it is identified with a "?".