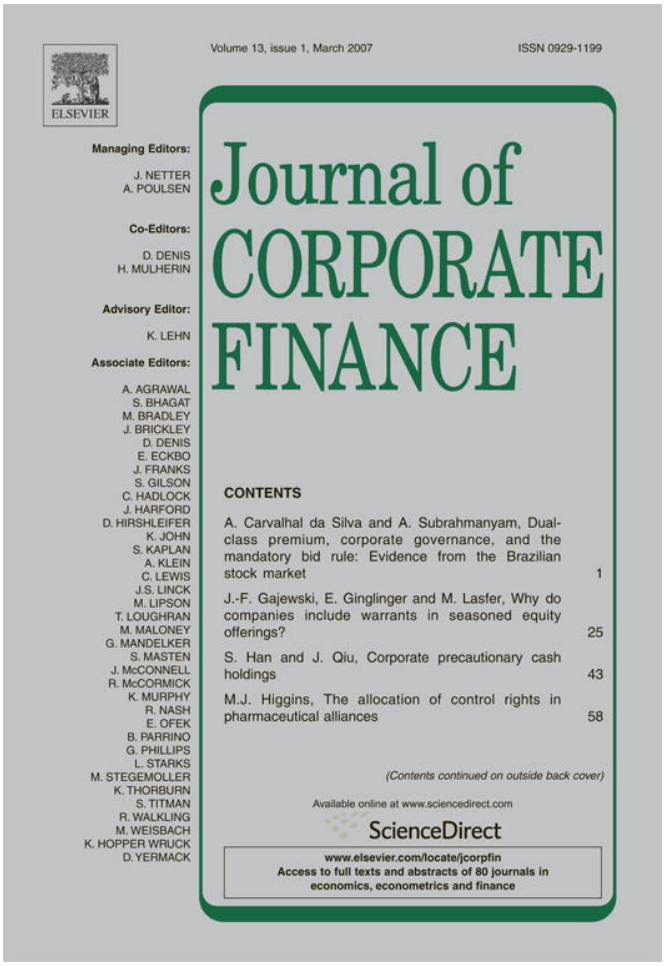

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The allocation of control rights in pharmaceutical alliances ☆

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Abstract

This paper uses alliances in the biopharmaceutical industry to test contractual theories of the firm. I find that the allocation of control rights between pharmaceutical and biotechnology firms is sensitive to the bargaining position of both parties. Pharmaceutical firms engaging in more costly, later stage alliances tend, on average, to relinquish more rights. Additionally, biotechnology firms entering their first alliance tend, on average, to relinquish more rights. Finally, I explore *if* and *when* alliances begin to impact pharmaceutical firm shareholder value. Overall, my findings indicate the importance of considering both parties to a contract when studying contractual design.

JEL classification: G32; L22
Keywords: Strategic alliances; Control rights; Biopharmaceutical industry; Contractual design

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1. Introduction

Since the seminal work of Coase (1937), economic research has considered the boundaries of the firm. Cheung (1983) notes that this research effort essentially entails analysis of the choice of contracts. Grossman and Hart (1986) and Hart and Moore (1988) extend this inquiry by modeling the incomplete contracting between a principal and an agent. They predict that property rights or control rights will be assigned to the contracting party with the greater marginal ability to impact output. Aghion and Tirole (1994) apply the Grossman-Hart-Moore framework to the structure of research and development (R&D) alliances. They model the contracts between a small research intensive firm and a larger manufacturer and predict that the relative bargaining position and the information advantages of the two firms will impact the allocation of control rights for an innovation.

Empirical analyses of R&D alliances, which have all focused solely on the bargaining power of the research firm, provide mixed support for the theory. Consistent with the theory, Lerner and Merges (1998) and Lerner et al. (2003) find that control rights are a function of proxies for bargaining power such as the availability of public financing. However, Lerner and Merges (1998) and Dessein (2005) report that control rights are less likely to be allocated to the research intensive firm in early stage projects. This finding appears to contradict the theory.

I provide new analysis of strategic alliances between research intensive biotechnology firms and larger pharmaceutical manufacturers. I develop cleaner tests of the extant theory, namely Aghion and Tirole (1994), by considering the bargaining power of *both* the research intensive firm (biotechnology firm) and the manufacturer (pharmaceutical firm). This is motivated in part by observations by Klein (1980) and Klein and Murphy (1997) that contracting parties are guided by both implicit (i.e., reputation) and explicit forces. This is in contrast to empirical work that holds the number and type of control rights allocated to the manufacturer constant. I also measure which, in addition to how many, control rights are allocated to the firms and which rights they tend to forgo. I also study the stock market response to the announcement of alliances to determine whether there is a link between bargaining power, the allocation of rights and shareholder value.

My results can be summarized succinctly. Like Lerner et al. (2003) I find that the condition of public equity markets and financial health are important determinants of the allocation of control rights. However, unlike Lerner et al. (2003), I find that measures of relative bargaining position negatively affect the control rights of the pharmaceutical firm. For example, pharmaceutical firms that have research pipeline concerns tend, on average, to give up control rights in later stage alliances. Like the prior research, I find that biotechnology firms relinquish more rights in earlier stage projects. However, these results are dampened when the relative bargaining position of the two parties to the alliance are considered. I also find that pharmaceutical firms experience positive wealth gains at the announcement of alliances. This is consistent with research by Chan et al. (1997) and McConnell and Nantell (1985). Interestingly, the market responds more favorably when fewer rights are allocated to the pharmaceutical firm. This is also consistent with the predictions of theory (Grossman and Hart, 1986; Hart and Moore, 1988; Aghion and Tirole, 1994).

The remainder of the paper is organized as follows: Section 2 describes the data and relevant variables; Section 3 presents and discusses the empirical findings; and I conclude in Section 4.

2. Data and sample

I study alliances between biotechnology firms and larger pharmaceutical manufacturers. The sources of data include Recombinant Capital, FDA Orange Book, Thomson Derwent, IMS

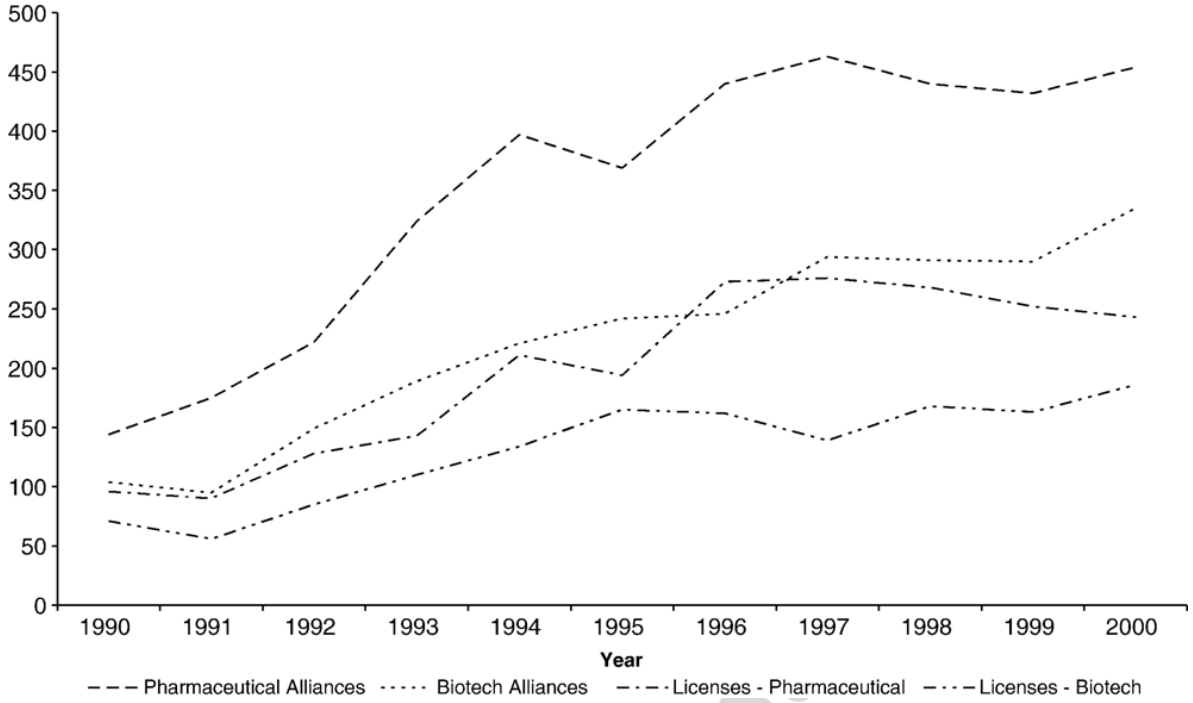

Fig. 1. The number of biopharmaceutical alliances is plotted between 1990 and 2000. Included in the figure are: the raw number of pharmaceutical alliances; the raw number of biopharmaceutical alliances; the number of pharmaceutical alliances which are classified as licenses; and, the number of biotechnology alliances which are classified as licenses. Data for the figure is drawn from Recombinant Capital.

Health, NDA Pipeline, Pharmaprojects, Securities Data Corporation (SDC), Center for Research in Security Prices (CRSP) and Compustat.

2.1. Alliances and determination of control rights

Recombinant Capital, a California-based biotechnology consulting firm, provided alliance information. Their data identifies alliances in the biopharmaceutical industry from 1973 up to the present. It provides both a general description as to the nature of the alliance together with detailed analyses of some of the alliance contracts. Between 1993 and 2000, 1169 alliances take place which involve just two parties (a pharmaceutical and biotechnology firm) and involve a license. This sub-sample is restricted to alliances involving two firms. The purpose of this is to be able to clearly identify the allocation of control rights. From this dataset, 165 alliances are randomly selected. Contracts with missing information were excluded and another contract was randomly selected. Fig. 1.

Recombinant Capital's choice of which alliance contracts to analyze *may* not be a random phenomenon. The non-randomness of this choice may introduce a selection bias into the sample; however, the direction and magnitude of a potential bias remains unclear. Therefore, the potential presence of factors which could strongly impact the chance for inclusion into the analysis process warrants the use of a Heckman selection model (Greene, 2003).

The dependent variable in the regression equation is *Total Rights* the total number of control rights allocated to the pharmaceutical firm. The independent variables for the regression equation are the same as those that will be used in subsequent analyses and will be discussed below. In no cases are any of the selection equation variables significant at least at the 10% level. Moreover, in every case the reported χ^2 test, which is equivalent to testing for $\rho=0$ (where ρ is the correlation

Table 1
Variable definitions

Variable	Definition/description
Score	Weighted value (non-monetary) of pharmaceutical firm research pipeline
R&D intensity	Pharmaceutical R&D expenses/sales (millions of 1999 dollars)
R&D firm shareholder equity	Biotechnology firm shareholder equity in the year of the alliance (billions of 1999 dollars)
Desperation Index	Dummy = 1 if pharmaceutical firm was assigned to desperation categories III or IV
Phase	Dummy = 1 if lead product that is focus of alliance is not yet in Phase I, Phase II or Phase III clinical testing
Public IPO funds raised	Amount of money raised in public equity markets by biotechnology firms in the year prior to an alliance (billions of 1999 dollars)
R&D payout	Pharmaceutical firm external R&D expenditures/total R&D expenditures (millions of 1999 dollars)
Pharmaceutical Firm Market Cap	Market capitalization of pharmaceutical firm (billions of 1999 dollars)
Size of deal	Total value of the alliance (millions of 1999 dollars)
Upfront payment	Dummy = 1 if upfront payments are present in the contract
Milestone	Dummy = 1 if milestone payments are present in the contract
Royalty	Dummy = 1 if running royalty payments are identified in the alliance contract
Δ Score	Change in weighted value (non-monetary) of pharmaceutical firm research pipeline ($year_t$–$year_{t-1}$)
Δ Exclusivity	Change in sales-weighted exclusivity horizon ($year_t$–$year_{t-1}$)
Total Rights	Total number of rights allocated to pharmaceutical firm (out of 10 possible rights)
Intellectual property rights	Total number of intellectual property rights allocated to pharmaceutical firm (out of 3 rights)
First	Dummy = 1 if the alliance was the first for the biotechnology firm

Definitions and descriptions of regression-model independent variables. Dependent variables utilized include *Total Rights* and *Partial Rights* in Tables 3 and 4.

between the error terms of the regression and selection equations), is not significantly different from zero. As a result, since ρ is not significantly different from zero, standard regression techniques can be applied to the regression equation without the concern of introducing a selection bias.

To avoid unnecessary heterogeneity, I exclude transactions where:

- One of the parties is a government agency or university.
- The alliance is a renegotiation or restatement of a previous alliance between the two firms.
- There is no research component to the alliance.
- One firm has a controlling interest in the other firm (greater than 50%).

I use a clustering technique to ensure that the sample of 165 alliances is representative of the population from which it was drawn. The initial sample of 1169 alliances is separated into the four distinct categories of the *Desperation Index* (discussed below). Firms are split amongst the four categories as follows: 64.5%, 2.2%, 29.1% and 4.2%, respectively. The final sample closely tracks the overall population with the following break-down across categories: 64.0%, 2.0%, 30.0% and 4.0%, respectively. Thus it can be claimed with a reasonable amount of confidence, that the sample closely mirrors the characteristics of the population from which it was drawn.

I reviewed each contract for relevant deal information including: the date and length of the alliance, technology and subject content, total value, upfront payments, royalty rates, contingent

Table 2
Descriptive statistics for firms making 165 strategic alliances in the 1993–2000

Variable	Mean	Median	Std. Dev.	Min	Max
Panel A: biotechnology and pharmaceutical firm characteristics					
Biotechnology firm					
Cash and equivalents in prior year ($)	41.5	9.8	179.7	0.3	1994.0
Total assets in prior year ($)	391.3	41.0	2509.8	1.8	27292.0
Shareholder equity in prior year ($)	212.5	31.9	1287.9	0.8	14077.0
Revenues in prior year ($)	272.2	7.8	2134.6	0	23995.0
R&D expenditures in prior year ($)	57.1	13.3	243.4	1.1	2634.0
Net income in prior year ($)	10.0	−8.8	269.0	−352.0	3003.0
Cash flows from operations in prior year ($)	44.3	−6.1	454.3	−63.8	4991.0
Pharmaceutical firm					
Cash and equivalents in prior year ($)	819.9	516.0	858.2	1.6	4278.0
Total assets in prior year ($)	10234.7	8437.0	8525.3	17.3	41578.0
Shareholder equity in prior year ($)	4581.4	3381.5	4099.3	10.1	20785.3
Revenues in prior year ($)	8628.8	6888.2	7782.7	13.2	37154.0
R&D expenditures in prior year ($)	1040.7	1033.9	1160.1	11.0	11542.5
External R&D payout/Total R&D (%)	0.046	0.021	0.094	0	0.761
Net income in prior year ($)	1398.5	1213.0	1356.4	−851.0	5890.5
Cash flows from operations in prior year ($)	1777.5	1524.6	1473.6	−73.5	6903.0
Panel B: alliance contract characteristics					
Phase of lead product					
Pre-clinical (%)	0.66			0	1
Phase I (%)	0.07			0	1
Phase II (%)	0.11			0	1
Phase III (%)	0.16			0	1
Alliance characteristics					
Presence of upfront payment (%)	0.83			0	1
Presence of royalty payment (%)	0.37			0	1
Presence of milestone payments (%)	0.90			0	1
Upfront payments ($ millions)	7.91	4.00	14.51	0	118.00
First alliance (%)	0.34		0.48	0	1
Royalty (% of net sales)	0.25	0.22	0.18	0.03	0.50
Milestone payments ($ millions)	32.82	14.00	47.17	0	225
Size of alliance ($ millions)	58.47	34.90	95.48	0.5	815.0
Biotech equity raised in prior year ($ millions)	106.6	111.4	26.9	65.4	156.9
Pharmaceutical financing in prior year ($ millions)	265.3	299.8	157.1	40.1	478.1
Allocation of control rights					
Control rights to pharmaceutical firm (out of 10)	4.52	4.00	1.56	1	10
Intellectual property rights (out of 3)	0.90	1.00	0.87	0	3
Exit strategy rights (out of 2)	0.64	1.00	0.64	0	2
License rights (out of 2)	1.13	1.00	0.62	0	2
Clinical trial/manufacturing rights (out of 3)	1.84	2.00	0.87	0	3
Length of alliance					
Five years from signing (%)	0.03			0	1
Ten years or greater from signing (%)	0.41			0	1
One to ten years *after* product approval (%)	0.03			0	1

Table 2 (*continued*)

Variable	Mean	Median	Std. Dev.	Min	Max
Panel B: alliance contract characteristics					
Length of alliance					
Greater than ten years *after* product approval (%)	0.40			0	1
Confidential — not disclosed (%)	0.13			0	1
Panel C: Desperation Index characteristics of pharmaceutical firms					
Category I firms — least desperate (%)	0.64			0	1
Category II firms (%)	0.02			0	1
Category III firms (%)	0.30			0	1
Category IV firms — most desperate (%)	0.04			0	1

Panel A presents characteristics of both the biotechnology and pharmaceutical firms. Panel B presents characteristics of the actual alliance contracts. Panel C presents the Desperation Index characteristics of the pharmaceutical firms. All values are in constant 1999 dollars.

or milestone payments, and R&D payments. Table 1 contains a description of the variables while Panel A in Table 2 summarizes this information. The average size of each alliance in the sample is approximately $58 million. (All values are in constant 1999 dollars.) Upfront payments are present in 83% of the deals and average $7.91 million. The median upfront payment is $4.0 million. Running royalty payments are identified in 37% of contracts and average 25% of net sales. The median running royalty is 22% of net sales. Milestone payments of some type are present in 90% of agreements. For products in their early stages and that have milestone terms available, the long-term financial rewards are very significant. Unfortunately, the probability that a product is successful from pre-clinical testing all the way to approval is very small, so the odds are against the biotechnology firm collecting on the full value of the milestone payments.

Contracts are also reviewed to determine the allocation of control rights. There is a broad spectrum of control rights that can be considered. The spectrum ranges from corporate governance, alteration in the scope of the alliance, control of technologies, disposition of patented and unpatented information and the control of clinical trials and subsequent manufacturing and marketing of developed products.

To identify which control rights are important, I combine an extensive review of the literature on biotechnology R&D alliances and alliance contractual design with input from industry practitioners, including the CEO and a head of alliance management at one of the top-five global pharmaceutical firms. Each of the ten rights chosen is sub-categorized for the purpose of analysis. Four sub-categories are used: intellectual property rights, exit strategy, license, and clinical trials and distribution. These sub-categories are summarized in Panel B of Table 2.

Intellectual Property Rights

1. Ownership of patents;
2. Control and responsibility for patent litigation process;
3. Transfer of unpatented R and D “know–how”;

Licensing Rights

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

Clinical Trial and Distribution Rights

6. Management of clinical trials;

7. Control of initial manufacturing process;
8. Marketing rights to the product;

Exit Rights

9. Product reversion rights upon termination; and,
10. Right to terminate without cause.

Note that there is a broad spectrum of control rights that can be considered when analyzing alliance agreements. The rights analyzed in this paper differ slightly from the five main control rights considered in Lerner et al. (2003). In Section 3.7, I consider Lerner et al's five rights in order to check the robustness of the current findings.

2.2. Exclusivity horizon and patent profiles

The bargaining position of the pharmaceutical firm is measured as a function of their patent profile, exclusivity horizon and product pipeline. I obtained relevant patent and exclusivity information from the FDA Orange Book and Thomson Derwent. Exclusivity refers to the exclusive marketing rights granted by the FDA upon approval of a new drug and is discussed more fully below. Three measures are generated for each pharmaceutical firm utilizing these data: (1) a patent profile, (2) an exclusivity profile, and (3) a sales-weighted exclusivity profile.

Focusing only on the years of exclusivity and patent protection that remains for a product create a major disadvantage; all products are weighted equally. Because some products are much more valuable than others in terms of revenue I construct a sales-weighted exclusivity horizon for each company. This variable is constructed from proprietary sales data obtained from IMS Health for every patented drug in the FDA's Orange Book files from 1993–2000. I combine the two datasets for each product to obtain a weighted product exclusivity horizon. Each product is weighted according to the proportion of sales represented by the average product life cycle of all drugs in the FDA Orange Book. The average product life cycle is determined as the proportion of sales in each year of exclusivity through three years following loss of exclusivity protection.

2.3. New drug applications (NDA) pipeline and score values

I construct a weighted value of each company's pipeline products using NDA Pipeline and Pharmaprojects files from 1993 to 2000. This measure is referred to as the *Score*. A relatively high *Score* indicates a healthy product pipeline versus a company with a lower value *Score*. A declining *Score* in the years prior to an alliance indicates a company whose product pipeline is deteriorating. Firms in this situation negotiate and bargain from a position of weakness. Conversely, an increasing *Score* value in the years prior to an alliance would indicate that a company's product pipeline is expanding and therefore they can bargain from a position of strength.

2.4. Desperation Index

Higgins and Rodriguez (2006) develop a unique *Desperation Index* to predict when pharmaceutical firms will engage in an R&D acquisition. I use this variable as the primary measure of a pharmaceutical firm's bargaining position. Each firm in the sample is placed into one of four categories of desperation based upon whether or not the change in their *Score* value and

Table 3
Ordinary least square (OLS) estimates from regressing *Total Rights* on selected independent variables for 165 strategic alliances

Dependent Variable: number of rights allocated to pharmaceutical firm								
Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Phase (=1 if not in clinical testing)	0.65 (1.89)[c]	0.73 (1.87)[c]	0.59 (1.95)[b]	0.68 (2.08)[b]	0.51 (2.39)[b]	0.45 (1.78)[c]	0.35 (2.59)[a]	0.41 (2.56)[b]
Biotechnology shareholder equity	−2.11 (5.73)[a]	−2.04 (5.62)[a]			−1.96 (3.65)[a]		−2.01 (2.95)[a]	
Public IPO funds raised (previous year)	−0.58 (2.79)[a]	−0.40 (2.35)[b]			−0.34 (3.33)[a]	−0.40 (1.95)[c]	−0.43 (2.57)[a]	−0.37 (1.81)[c]
R&D Intensity			0.42 (2.28)[b]	0.52 (1.72)[a]		0.56 (2.19)[b]		0.57 (3.03)[a]
Pharmaceutical firm market capitalization			0.14 (0.92)	0.16 (1.06)	0.07 (1.75)[c]	0.05 (0.72)	0.06 (1.51)	0.05 (1.18)
Desperation Index			−0.53 (1.99)[b]	−0.57 (1.94)[b]	−0.29 (2.07)[b]	−0.33 (1.70)[c]		
Δ score							0.38 (1.72)[c]	0.31 (2.21)[b]
Δ exclusivity							0.10 (1.76)[c]	0.13 (1.70)[c]
Size of deal (millions)		−0.02 (2.27)[b]	−0.03 (3.29)[a]	−0.04 (3.47)[a]		−0.03 (2.38)[b]		−0.04 (2.45)[b]
Upfront payment (=1 if present)		0.01 (0.02)		0.16 (0.68)				
Milestone (=1 if present)		−0.11 (0.22)		0.14 (0.50)				
Royalty (=1 if present)		0.15 (0.46)		0.28 (0.60)				
First	0.34 (2.18)[b]	0.29 (1.97)[b]	0.52 (1.86)[c]	0.49 (1.75)[c]	0.29 (1.99)[b]	0.31 (2.03)[b]	0.47 (1.75)[c]	0.43 (1.77)[c]
Constant	4.18 (4.51)[a]	4.32 (4.57)[a]	4.80 (5.91)[a]	3.69 (5.56)[a]	4.38 (3.77)[a]	3.72 (4.85)[a]	4.03 (3.11)[a]	3.81 (4.62)[a]
R^2	0.11	0.09	0.08	0.07	0.09	0.08	0.09	0.10
Observations	68	68	153	153	68	153	68	153

The period of analysis runs from 1993 to 2000. Models 1 and 2 focus on the bargaining position of the biotechnology firm while Models 3 and 4 focus on the bargaining position of the pharmaceutical firm. Models 5 thru 8 control for the bargaining position of both firms. Fixed effects are included in all specifications. White's heteroskedasticity-consistent *t-statistics* are reported in parentheses. See Table 1 for variable definitions. [a]Denotes significance at the 1% level; [b]denotes significance at the 5% level; and, [c]denotes significance at the 10% level.

sales-weighted exclusivity horizon is increasing or decreasing in the period immediately prior ($year_t$–$year_{t-1}$) to an alliance. Categories I–IV reflect an increasing level of desperation. Category I (strongest position) represents firms with an increasing *Score* value and an increasing sales-weighted exclusivity horizon. Category II represents firms with increasing *Score* values, but a declining sales-weighted exclusivity horizon. In contrast, a Category III firm is generating increasing sales, but has a declining *Score* value. Finally, Category IV (weakest position) represents firms with both decreasing *Score* values and a decreasing sales-weighted exclusivity horizon. For the purposes of the regressions that follow, the *Desperation Index* equals one if the firm is assigned into either Category III or Category IV. 34% of the pharmaceutical firms in the sample fall into this categorization.

2.5. Financial data

Financial data for both the pharmaceutical and biotechnology firms is summarized in Panel A of Table 2 and is obtained primarily from Compustat. Some financial data is supplemented from individual firm's filings or corporate internet sites. Biotechnology initial public offering (IPO) data is obtained from Securities Data Corporation (SDC). Pharmaceutical firm external R&D data is collected from Recombinant Capital.

3. Empirical findings

3.1. Allocation of control rights — biotechnology firm

The first prediction I consider is a direct empirical test of Aghion and Tirole (1994). These results are presented in Models 1 and 2 on Table 3. Consistent with previous work (Lerner and Merges, 1998; Lerner et al., 2003; Lerner and Malmendier, 2004; Adegbesan and Higgins, 2006), the total number of control rights allocated to the pharmaceutical firm is the dependent variable. The dependent variable is tested against various specifications of the following ten independent variables: a dummy indicating whether the alliance involved a drug treatment in clinical phase testing; the shareholder equity of the biotechnology firm (billions of 1999 dollars); the total amount of public IPO funds raised by biotechnology firms in the year prior to the alliance (billions of 1999 dollars); a unique measure of a pharmaceutical firm's desperation (*Desperation Index*); the size of the deal (millions of 1999 dollars); a dummy variable indicating the presence of upfront payments; a dummy variable indicating the presence of milestone payments; and, a dummy variable indicating the presence of royalty payments.

The specification presented in Model 1 attempts to replicate the empirical results of Aghion and Bolton (1992), Holmstrom and Tirole (1997) and Lerner et al. (2003). They find that research projects in earlier stages of development, which are presumably those with larger information asymmetries and in greater need of financing, are associated with a transfer of control rights to the pharmaceutical firm. The variable *Phase* equals one if the lead product in the alliance is not yet in any stage of phase clinical testing. The coefficients in Model 1 and Model 2 are 0.65 and 0.73, respectively. Both are significant at the 10% level. These results imply a transfer of approximately two-thirds to three-quarters of one right to the pharmaceutical firm for early stage projects and are consistent with the aforementioned empirical work.

The financial strength of the biotechnology firm is measured by the variable *Biotechnology Shareholder Equity*. Consistent with Lerner and Merges (1998), biotechnology firms in stronger financial positions retain more rights. In Model 1 this amounts to the retention of around two additional rights.

The impact on the external financing market has on the allocation of control rights is measured next. Specifically, the availability of public IPO funds in the year prior to an alliance (*Public IPO Funds Raised*) is considered. In periods of limited resource availability, biotechnology firms turn to pharmaceutical firms for financing, thereby weakening their bargaining position. The weaker position causes them to relinquish additional rights (Aghion and Bolton, 1992; Holmstrom and Tirole, 1997; Lerner et al., 2003). The results support this claim. The condition of the public financing markets accounts for around one-half of a right. This result fluctuates across various specifications, but remains robust and ranges from negative 0.34 to negative 0.58. All but one specification is significant at least at the 1% or 5% level. In all cases, however, the direction of the transfer of rights remains the same; in periods

of limited availability of public financing additional rights are given up to the pharmaceutical firm.

To test the robustness of the external financing measure, *Public IPO Funds Raised*, I repeat these regressions switching out the *Public IPO Funds Raised* variable with *R&D Payout*. *R&D Payout* is a measure of the percentage of R&D funds a pharmaceutical firm allocates to external R&D projects in a given year. This percentage should increase in periods of limited external financing as more biotechnology firms turn to them for alliance financing. The variable is constructed using data from Recombinant Capital and Research Insight. In each year, new alliances for every firm are identified. The cumulative amount of funding they commit to these ventures is divided by the firm's total R&D spending, generating a variable by year that describes the proportion of the R&D budget utilized on external research. In the present sample, *R&D Payout* averages about 4.6% for pharmaceutical firms. This variable is not significant at any reasonable level.

In an effort to understand whether or not pharmaceutical firms simply *pay* for additional rights I introduce four additional independent variables in Model 2. The three independent variables discussed in Model 1 remain robust to this specification. Additional independent variables now include: size of the deal (millions), a dummy indicating the presence of an upfront payment, a dummy indicating the presence of milestone payments and a dummy indicating the presence of royalty payments. The effect of the size of the deal is minimal, but suggests a negative relationship with the number of rights allocated to the pharmaceutical firm. This finding may be tied to the phase of the product which is the focus of the alliance. This discussion will be delayed until Section 3.4, where I address this question in more detail. The remaining three independent variables explore whether the pharmaceutical firm is extracting additional rights through the use of larger upfront payments, milestone payments or running royalties. None of these variables are significant across any specification. Collectively, these results imply that pharmaceutical firms are not paying for additional control rights.

While some of the results discussed above replicate the extant literature, it is important to show that the current dataset follows similar trends to those previously reported. Because they do it is reasonable to suggest that the results are not simply a function of the alliances or specific rights chosen.

3.2. Allocation of control rights — pharmaceutical firm

Model 3 and Model 4 on Table 3 consider factors impacting the bargaining position of the pharmaceutical firm. The primary measure of bargaining position is embodied in the *Desperation Index*. In addition to testing the desperation level of a firm, I also consider *R&D Intensity* of the pharmaceutical firm. Pharmaceutical firms must have the internal capacity to digest externally acquired research into their own R&D programs (Chesbrough, 2003). Cohen and Levinthal (1990) postulate that a firm's R&D intensity will be based on their internal research efforts. Therefore, regardless of the external R&D activities that a pharmaceutical firm may conduct, it will remain important for the firm to continue to pursue a comprehensive internal research program.

The previous discussion focused on the financial resources available to the biotechnology firm. By contrast, here the focus is on what matters most to the pharmaceutical firm — a continual flow of patented products. In both Model 3 and Model 4 on Table 3, pharmaceutical firms experiencing greater levels of desperation (*Desperation Index*) relinquish approximately one-half of a right to biotechnology firms. These findings are robust across additional specifications and remain significant at least at the 5% level.

Variable *Desperation Index* is parsed into its individual parts, Δ *score* and Δ *exclusivity* in an effort to identify which component drives firm level desperation. Variable Δ *score* measures the change in a firm's weighted research portfolio between the year of the alliance and the year prior to the alliance. Variable Δ *exclusivity* measures the change in a firm's sales-weighted exclusivity horizon between the year of the alliance and the year prior. In replications of the above analysis including these variables, the effects of Δ *score* are more relevant than the effects of Δ *exclusivity*. Coefficient estimates for Δ *score* range between 0.35 and 0.47 and are significant at least at the 5% level. The change in health of a pharmaceutical firm's research portfolio is worth about one-third of a control right. Coefficient estimates for Δ *exclusivity* range from 0.06 to 0.10; however, these estimates are rarely significant at even the 10% level. This implies that changes to a pharmaceutical firm's research pipeline impact their bargaining position more than changes in their patented product sales. This result has some intuitive appeal. Pharmaceutical firms entering research alliance agreements – many of which are at early stages – are often doing so to replenish research pipelines and not necessarily patented product portfolios.

3.3. Allocation of rights and relative bargaining position

Models 5 thru 8 on Table 3 present results where *both* the pharmaceutical and biotechnology firm's bargaining position is interacted to determine whether the allocation of rights changes in any meaningful manner. The independent variables remain unchanged except for the removal of the upfront, milestone and royalty dummies. In unreported regressions, none of these variables are significant.

The coefficient on *Phase* remains positive and significant across all specifications. The magnitude of the coefficient has fallen compared with the results in Models 1 to 4. When the bargaining position of both firms is taken into account, *Phase* accounts for approximately one-third to one-half of a right compared to over one-half of a right in the previous analysis. In this setting, pharmaceutical firms extract fewer rights from biotechnology firms in alliances involving earlier stage products. At the same time however, they relinquish fewer rights to biotechnology firms in alliances involving later stage products.

The coefficient on *Biotechnology Shareholder Equity* remains relatively unchanged. Consistent with Lerner et al. (2003), it is the single largest factor impacting the allocation of rights. Almost two full rights are relinquished to pharmaceutical firms by biotechnology firms with limited assets. In contrast, the coefficient on *Public IPO funds raised* increased; however, it remains negative. The limited availability of public financing in these specifications accounts for around one-third of a right versus one-half of a right in the previous models.

Shifting attention to the bargaining position of the pharmaceutical firm, the coefficient on *R&D Intensity* marginally increases to just over one-half of a right and remains significant at least at the 5% level. This confirms the importance of a pharmaceutical firm maintaining internal capacities along the lines of those discussed by Cohen and Levinthal (1990), Teece et al. (1997), and Chesbrough (2003).

Pharmaceutical Firm Market Capitalization has minimal impact on the allocation of rights and continues to be barely significant at the 10% level. The implication here is that pharmaceutical firms are unable to garner any additional rights simply because of their size. This is impressive given the disparity in the sizes of the two firms and the significant impact that the financial health of the biotechnology firm has on the allocation of rights.

The coefficient on the variable *Desperation Index* becomes less negative; however, it is significant at the 5% level. In Model 5 and Model 6, about one-third of a right is relinquished by

pharmaceutical firms identified as *more desperate*. The loss in rights due to firm level desperation negates the gains that pharmaceutical firms receive as a result of limited availability of public financing for biotechnology firms. When the *Desperation Index* variable is parsed into its two component parts in Models 7 and 8 — Δ *score* and Δ *exclusivity*, both coefficients are positive and significant.

When the bargaining positions of the two firms are considered together the biotechnology firm is impacted more significantly than their pharmaceutical partner. Clearly, the factors impacting the pharmaceutical firm's bargaining position in Models 3 and 4, while still significant, have been muted to some degree. In contrast, the factors impacting the bargaining position of the biotechnology firms persist.

3.4. Stage of research and the allocation of control rights

The results in Section 3.1 demonstrate that the size of the alliance is negatively related to the number of rights allocated to the pharmaceutical firm. Generally, the largest deals involve products in the later stages of development. The average size of an alliance for products in the early stage development is $53 million (including upfront and maximum milestone payments). The average size of an alliance for products in late stage clinical testing is $97 million (including upfront and maximum milestone payments). These figures exclude royalty payments since any determination of potential income is wholly speculative. Notwithstanding this exclusion, running royalty rates for these deals are available. The average royalty rate in contracts with early stage research average 19.9% of net sales while the average royalty rate in contracts that involve late stage products average 36% of net sales. Simple correlations between size of the deal and phase of the lead product increase as a patented product is further developed.

The analysis in Table 3 is repeated, replacing *Phase* with dummy variables for the latter two stages of clinical testing — *Phase II* and *Phase III*. Variable *Phase I* is omitted. The variables equal one if the lead product in the alliance falls within that particular phase of clinical testing. In all specifications, the coefficients are negative with the coefficient on *Phase III* consistently more negative than the coefficient on *Phase II*. In unreported regressions, the coefficient on *Phase II* ranges from negative 0.42 to negative 0.51 and is significant at least at the 10% level. The coefficient on *Phase III* ranges between negative 0.63 to negative 0.83 and is significant at least at the 5% level. This implies that the pharmaceutical firm relinquishes more rights as the lead product in the alliance is more advanced in development. The time for pharmaceutical firms to enter these alliances is when the research is at an early stage, otherwise they risk losing rights to the biotechnology firm.

This finding complements Higgins and Rodriguez (2006). The combined results suggest that pharmaceutical firms seeking early-stage research may best accomplish their goal using strategic alliances. However, as projects move further along the development process, pharmaceutical firms give up more rights if they try to access those products via an alliance. As a result, it may be more beneficial for firms to make an acquisition, acquire all of the rights and avoid any potential costly holdup issues (Klein, 1980; Klein and Murphy, 1997).

3.5. Allocation of rights and shareholder value

Adegbesan and Ricart (2005) find that innovation might not significantly improve a firm's performance if value is asymmetrically appropriated by one of parties to the agreement. Looking at announcement period responses is one way to gauge the market's perceptions of an agreement. Table 4 presents univariate announcement period cumulative abnormal returns (*CAR*s) in two

Table 4
Event study estimates evaluating the cumulative abnormal return versus the presence of various independent variables

Panel A: univariate CAR results by control right groups

Variable	Pharmaceutical firm		Biotechnology firm	
	Less than 50%	Greater than 50%	Less than 50%	Greater than 50%
Total Rights	0.0130 (3.03)[a] $n=79$	0.0081 (1.31) $n=74$	0.0163 (1.25) $n=24$	0.0347 (2.97)[a] $n=44$
Intellectual Property Rights	0.0135 (3.23)[a] $n=122$	−0.0008 (0.11) $n=31$	0.0247 (1.45) $n=18$	0.0412 (3.13)[a] $n=50$
Exit Rights	0.0101 (1.08) $n=68$	0.0110 (2.01)[b] $n=85$	0.0071 (0.97) $n=32$	0.0009 (1.25) $n=36$
Licensing Rights	0.0091 (1.12) $n=21$	0.0107 (2.63)[b] $n=132$	0.0045(1.49) $n=42$	0.0268 (1.34) $n=26$
Manufacturing Rights	0.0096 (3.19)[a] $n=49$	0.0127 (1.87)[c] $n=104$	0.0097 (0.44) $n=52$	0.0071 (0.005) $n=16$

Panel B: univariate pharmaceutical CAR results by payment structures

Variable	CAR	Variable	CAR
Upfront Payments		Royalties	
Yes	0.0105 (2.40)[b] $n=128$	Yes	0.0139 (3.13)[a] $n=96$
No	0.0113 (2.72)[a] $n=25$	No	0.0051 (0.78) $n=57$
Milestone payments			
Yes	0.0091 (2.48)[b] $n=139$		
No	0.0263 (1.41) $n=14$		

Panel A presents three-day univariate results for pharmaceutical and biotechnology firms focusing around the allocation of rights while Panel B presents three-day univariate results for pharmaceutical firms based around financing mechanisms. *t*-statistics are reported in parentheses. See Table 1 for definitions of variables.

[a] Significant at the 1% level.
[b] Significant at the 5% level.
[c] Significant at the 10% level.

separate panels. A five day event window is also tested. Results are not qualitatively different from the three-day window. Panel A presents univariate results based on the allocation of rights while Panel B presents univariate results based upon payment structures. *CARs* are calculated for three and five day event windows, where the event is defined as the public announcement of the alliance. The three-day pharmaceutical firm *CAR* is 1.06% and the five day pharmaceutical firm *CAR* is 0.84%. Both are significant at least at the 5% level. These *CAR* results are in-line with those reported by Chan et al. (1997) and McConnell and Nantell (1985). Announcement period gains accruing to biotechnology firm shareholders over a three-day window are 7.01% while the five day window is 6.45%. Both are significant at the 1% level.

Interestingly, the market responds more favorably when fewer rights are allocated to the pharmaceutical firm. Three-day *CAR*s are 1.3% when fewer than 50% of the *Total Rights* are allocated to the pharmaceutical firm. These results are significant at the 1% level. Likewise, three-day *CAR*s are 3.47% when more than 50% of the *Total Rights* are allocated to the biotechnology firm. These results are significant at the 1% level. When more than 50% of the *Total Rights* are allocated to the pharmaceutical firm the results are not significant at any level. While the empirical results in Sections 3.1–3.3 appear to suggest that biotechnology firms are relinquishing rights in order to obtain financing, the market appears to be rewarding the exact opposite. In fact, the market appears to be rewarding a pattern consistent with the theoretical predictions of Aghion and Tirole (1994).

The remaining results in Panel A present the three-day univariate *CAR*s based on the main subgroupings of rights discussed in Section 2.1: intellectual property rights, exit rights, licensing rights and manufacturing rights. Two results in particular are worth mentioning. First, the market

responds more favorably when fewer than 50% of the *Intellectual Property Rights* are allocated to the pharmaceutical firm. Pharmaceutical firm *CARs* are 1.35% and significant at the 1% level. When more than 50% of the rights are allocated to the biotechnology firm, *CAR*s are 2.08% and significant at the 1% level. This result can be interpreted as the market rewarding the firms for a "correct" allocation of rights. Because biotechnology firms are first and foremost research engines, protecting their intellectual property rights is of paramount importance.

Second, the market reacts positively for those pharmaceutical firms allocated more than 50% of the *Exit Rights*. Pharmaceutical *CAR*s are 1.1% and significant at the 5% level. There is a moral hazard problem in biopharmaceutical alliances. Pharmaceutical firms need to ensure that the funds they are providing to their biotechnology partners are not diverted to other research projects. Research funds are fungible across R&D projects and given limited firm revenues and cash flows, there is an incentive to swap funds. Lerner and Malmendier (2004) study this issue and find that in situations where there is no specific lead candidate (i.e., earlier stage research) it is optimal for the pharmaceutical firm to maintain the termination or exit rights. Such an allocation helps prevent the biotechnology firm from deviating from the contracted research agenda.

Interestingly, the pattern of the allocation of *Exit Rights* does not change over time or with repeated contact between firms. Parkhe (1993) and Ciccotello and Hornyak (2000) find some evidence of reduced contractual safeguards between firms engaging in repeated contacts. Along with Gulati (1995) they attribute this to increased levels of trust. Since the number of pharmaceutical firms operating in a particular therapeutic category is relatively small, one would expect that the possibility of creating future relationships would prevent biotechnology firms from abrogating their responsibilities. Likewise, as Klein (1980) and Klein and Murphy (1997) discuss, firms with unequal bargaining power, in this case pharmaceutical firms, will also not act opportunistically as this could damage their reputation and limit their potential future alliance partners. Notwithstanding this, the allocation of exit rights tends not to change.

Panel B focuses on the market reaction to the different payment structures of the alliances. These results are mixed. The returns to pharmaceutical firms when upfront payments are not included are higher than when they are present, 1.13% versus 1.05%, for the three-day window. Both are significant at least at the 5% level, but they are not significantly different from each other.

The market appears to prefer deals containing milestones. Pharmaceutical firms have smaller initial financial outlays and will only be required to inject cash if specific research milestones are accomplished. As a result, this should be viewed positively by the market. Unfortunately, while the three-day *CAR* is 0.91% and significant at the 5% level for alliances that include milestone payments, the result is not significantly different from the deals that do not include milestones.

Royalty payments can help to alleviate the inherent moral hazard problem in these types of research arrangements. Jensen and Thursby (2001) find that royalty payments help alleviate moral hazard problems with regard to inventor effort. Since monies are deferred and payable only if specific objectives are met, the biotechnology firm has an interest in supplying full effort to the agreement. Pharmaceutical firm *CARs* that include royalty payments are 1.39% and significant at the 1% level.

Cross-sectional regression results are reported in Table 5. The dependent variable in these specifications is the three-day pharmaceutical firm *CAR*. The independent variables remain the same. In all specifications the coefficient on variable *Phase* is positive and significant. There is a positive impact on the magnitude of the *CAR*s when pharmaceutical firms enter into alliances where products are in earlier stages of development. Alternatively, pharmaceutical *CAR*s are negatively impacted when the alliance involves later stage products. Alliances involving later stage products can be seen as a sign of weakness in their research pipeline. As noted earlier, Higgins and Rodriguez

Table 5
Cross-sectional regression estimates from regressing cumulative abnormal return (CAR) on selected independent variables for 153 announcements of strategic alliances

Dependent variable: pharmaceutical firm cumulative abnormal returns (CARs)				
Variable	Model 1	Model 2	Model 3	Model 4
Phase (=1 if not in clinical testing)	0.0276 (3.40) [a]	0.0231 (3.08) [a]	0.0292 (2.90) [a]	0.0253 (3.05) [a]
Total Rights (pharmaceutical firm)	−0.0158 (1.65) [b]	−0.0137 (1.59)	−0.0156 (1.62)	−0.012 (1.61)
R&D Intensity		0.0341 (1.69) [b]	0.0285 (1.93) [b]	0.0306 (1.73) [b]
First	0.0379 (1.71) [b]	0.0259 (1.82) [c]	0.0278 (1.63)	0.0253 (1.79) [b]
Desperation Index	0.0072 (0.82)		0.0030 (0.27)	
Δ score		0.0268 (2.05) [c]		0.0302 (2.32) [c]
Δ exclusivity		0.0107 (1.09)		0.0118 (1.31)
Upfront dummy (=1 if present)			−.0016 (1.12)	
Royalty dummy (=1 if present)			0.0002 (0.02)	
Milestone dummy (=1 if present)			0.0108 (1.80) [b]	0.0163 (2.01) [b]
Constant	0.0995 (7.08) [a]	0.1692 (7.54) [a]	0.0726 (6.54) [a]	0.0442 (6.76) [a]
R^2	0.059	0.072	0.062	0.074
Number of observations	153	153	153	153

CARs are from the three-day event window which includes the day of the announcement along with the day prior and day after the announcement. The period for this analysis runs from 1993–2000. Fixed effects are included in all specifications. White's (1980) heteroskedasticity-consistent *t*-statistics are reported in parentheses. See Table 1 for variable definitions.
[a] Significant at the 1% level.
[b] Significant at the 10% level.
[c] Significant at the 5% level.

(2006) find that pharmaceutical firms in this position are more likely to engage in acquisitions. If this is the case, then acquisitions and not alliances may be the more appropriate activity.

The coefficient on *Total Rights* is negative; however, it is only significant at the 10% level in one of the reported specifications. This result is consistent with the results presented in Panel A of Table 4. Those results imply that pharmaceutical firm shareholders are rewarded when the firm is allocated less than 50% of rights. Table 5, in conjunction, shows a negative impact on the magnitude of the *CAR* as more rights are afforded to the pharmaceutical firm. Theory predicts that more rights should flow to the biotechnology firm; while the empirical literature, including this paper, finds the opposite. However, it appears that the coefficient on *Total Rights* is reacting in a manner that supports the theoretical literature. Unfortunately, it is significant in only one of the four models.

Chesbrough (2003), Teece et al. (1997), and Cohen and Levinthal (1990) argue that firms must have the internal capacity or absorptive capacity to effectively absorb external research. The positive and significant coefficient on *R&D Intensity* supports these claims.

While the overall impact of the *Desperation Index* is not significant in any of the specifications tested, a different picture arises when the variable is parsed into its two component parts. Δ *score* is positive and significant across the various specifications — ranging in magnitude from 0.0268 to 0.0302. On the other hand, Δ *exclusivity* is positive but it is not significant. This suggests that the health of the pharmaceutical firm's research pipeline impacts the magnitude of the *CAR*.

Variable *Milestone* is a dummy that equals one if there are milestone payments present in the alliance contracts. The coefficient on *Milestone* is both positive and significant. Milestone payments are relevant for several reasons. First, as discussed earlier, companies are not required to inject 100% of a project's potential financing at the initiation of an alliance. From Panel B of Table 2, approximately 13% of the value of the overall alliance is paid out upfront. The remainder is paid over various milestones. Second, milestone payments help with the moral hazard problem

inherent in these types of contracting situations. Therefore, the presence of milestone payments should be viewed as a positive event for pharmaceutical firms.

In unreported regressions, the dependent variable is changed from the pharmaceutical *CAR* to the biotechnology *CAR*. In these regressions, the number of observations falls to 68 due to the number of privately held biotechnology firms in the sample. Three results are worth noting. First, there is a negative and significant relationship between the biotechnology *CAR* and the number of rights allocated to the pharmaceutical firm. Second, there is a negative and significant relationship between the biotechnology *CAR* and the pharmaceutical firm Δ *score*. This is consistent with the previous finding that pharmaceutical firms with deteriorating pipelines relinquished more rights to the biotechnology firms. It appears to be demonstrating the market reaction to their loss of rights. Finally, there is a positive and significant relationship between the biotechnology *CAR* and *upfront dummy*. These results are all consistent across the various specifications tested and flow in the expected direction.

3.6. First alliances and the biotechnology firm

Nicholson et al. (in press) find that biotechnology firms receive substantial discounted valuations in their first alliance with a pharmaceutical firm. They argue that these biotechnology firms are willing to accept lower initial valuations because the alliance with the pharmaceutical firm serves as a positive signal to prospective investors. These same firms subsequently received higher valuations from venture capitalists and the public equity markets. Presumably, a biotechnology firm would be willing to cede additional control rights for the same reason they were willing to cede value. If the biotechnology firm accepts a lower initial valuation, the pharmaceutical firm should receive the added benefit. Likewise, the pharmaceutical firm will receive the additional control rights.

The results of testing whether biotechnology firms relinquish additional rights on first alliances are presented in Table 3. Across all specifications tested, biotechnology firms give up anywhere from one-quarter to one-half of a right if they are engaging in a first alliance with a pharmaceutical firm. These results do not suggest, however, that these rights are relinquished willingly. Nicholson et al. (in press) finds that firms are willing to accept a diminished initial valuation; it seems reasonable that they would also be willing to forgo control rights for the same reason(s).

If the pharmaceutical firm receives both favorable alliance valuations and additional control rights, it is reasonable to suggest that this should be reflected positively in the market reaction to the announcement of an alliance. Table 5 presents the results of testing whether variable *First* has an impact on the magnitude of the pharmaceutical firm's *CAR*s. In most specifications the impact on the magnitude on the *CAR* is positive and significant, at least at the 10% level. Additionally, since variable the *Total Rights* controls for the number of rights allocated to the pharmaceutical firm the positive coefficient on *First* may be detecting the effects of discounted biotechnology firm valuations as discussed by Nicholson et al. (in press).

3.7. Robustness

To ensure the robustness of the results to model selection, I regenerate the results from Table 3 using both ordered logit and negative binomial specifications. None of the results presented are qualitatively different using either of these specifications.

Many different control rights can be considered in this type of analysis. This paper considers ten such rights. However other work, namely Lerner et al. (2003), consider rights groupings. They focus on five main rights: management of clinical trials, control of the initial manufacturing process, control

of manufacturing after product approval, retention of all sales categories by the pharmaceutical firm, and the ability to exclude the biotechnology firm from all aspects of the financing process. Of these five primary rights, they focus on three included in the bundle of rights considered in this paper. To help ensure that a particular bundle of rights is not driving the results, the five specific rights considered by Lerner et al. (2003) are used to test the robustness of the results presented in Tables 3 and 5. The main findings in Table 3 remain qualitatively consistent when the rights are swapped out. Additionally, when variable *Total Rights* in Table 5 is redefined as the five main rights considered by Lerner et al. (2003) the results, again, are not qualitatively different. The choice of which bundle of rights to include or exclude does not appear to impact the findings of this paper.

4. Conclusion

This paper has focused on the contractual terms of alliances between pharmaceutical and biotechnology firms. More specifically, I explore the impact that firm bargaining position has on the overall allocation of rights. In addition, I also measure the impact that bargaining position and the subsequent allocation of rights has on pharmaceutical firm shareholder value. An attempt is also made to understand *if* and *when* the allocation of control rights begins to impact underlying shareholder value. As many of the large pharmaceutical companies have extensive portfolios of alliances, the allocation of rights is important in how the firm will eventually benefit from an alliance.

Several contributions are made to the literature. First, I find evidence that relative bargaining position impacts the underlying allocation of rights. When both firms' bargaining positions are taken into consideration, the factors impacting the biotechnology firm are the most important. Second, I find that the stage of the lead product which is the focus of the alliance is significant in the overall allocation of rights. Pharmaceutical firms tend, on average, to give up more rights in later stage alliances. Third, pharmaceutical firms that negotiate from a position of relative strength, either because they are less desperate or the biotechnology firm is more desperate, garner a more favorable bundle of rights. Coupled with the second finding and Higgins and Rodriguez (2006), this suggests that pharmaceutical firms that are more desperate may be better off engaging in acquisitions instead of alliances due to the cost and the number of rights they forgo. Fourth, biotechnology firms entering their first alliance with a pharmaceutical firm tend, on average, to give up more rights. Finally, I find positive cumulative abnormal returns (*CARs*) accruing to pharmaceutical firm shareholders surrounding the announcement of the alliance. Markets respond more favorably when *fewer* rights are allocated to the pharmaceutical firm. They appear to be rewarding an allocation of rights that is predicted by theory.

The existing empirical research has had mixed success in supporting theory, such as Grossman and Hart (1986) and Hart and Moore (1988). My innovation has been to consider the bargaining power of both the research intensive (biotechnology) firm and larger client (pharmaceutical firm). This is motivated, in part, by observations by Klein (1980) and Klein and Murphy (1997) that contracting parties are guided by both implicit (i.e., reputation) and explicit forces. Future work might consider in more depth the role of the reputational constraints on contracting parties.

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