Valuing Biopharmaceutical Alliances

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ABSTRACT

Strategic alliances among firms in the biopharmaceutical industry (pharmaceutical and biotechnology firms) have increased significantly over the past decade, and particularly over the last three years. This paper applies an event study analysis to 123 alliances in this industry over the last three years, to determine the magnitude of the value creation resulting from these alliances. This paper also completes a cross-sectional analysis using partner characteristics and alliance characteristics to determine some of the potential sources for this value creation. We find that the R&D partner firms in these alliances experience significant positive cumulative abnormal returns of 4.4%. We also find that equity participation is associated with more valuable alliances and that alliances involving complex diseases result in lower value creation. R&D partner firms that had yielded low returns prior to an alliance experience a significant positive effect as a result of the alliance announcement. The result of lower value creation for complex disease alliances is consistent with higher transactions costs involved in completing such alliances. Unlike a previous study that considers alliances across twenty different industries, our analysis finds that research and marketing alliances within the biopharmaceutical industry are equally valuable.

I. Introduction.

The widely respected chief of research at Roche Holdings, Jurgen Drews, made the following recent pronouncement regarding alliances in the pharmaceutical industry:

> It will be necessary for the pharmaceutical company wishing to develop drugs rapidly from the Human Genome project to form alliances with many partners---in both biotechnology and academia---to carry out this process as efficiently and as effectively as possible.[1]

Strategic alliances have become increasingly common in several research-intensive industries, including the telecommunications industry, the computer hardware and software industry, and the pharmaceutical and biotechnology industries (or biopharmaceutical industry). Table 1 lists the ten US firms engaged in the greatest number of alliances from 1990-96. Three of these top ten firms (Bristol-Myers Squibb, Eli Lilly, and Merck) are well-established pharmaceutical firms.[2] Combined over this seven-year period, they have participated in a total of 278 alliances, with many of these alliances occurring over the past three years. A number of recent books published primarily for business students and professionals have lauded the significant benefits of these alliances for their participants.[3] Management guru Drucker (1995) describes the growing importance of alliances generally as the "greatest change in corporate structure—and in the way business is being conducted." Interestingly, though alliances have existed for several decades in Corporate America, they have not become a

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[1] Drews (1996:1518).

[2] Theil (1997) notes that "Eli Lilly & Co., an elder statesman of the pharmaceutical industry, has been showing an almost youthful enthusiasm for dealmaking this year. Indianapolis' favorite son has formed 19 R&D collaborations so far in 1997 [over the first seven months of the year], a huge increase from the seven agreements for 1996 (three of which were mere renewals)."

[3] Brandenburger and Nalebuff (1996) have recently published a business strategy text that incorporates cooperative agreements as a viable strategy. Preiss (1996) provides an overview of the importance of strategic alliances in today's business environment. Gomes-Casseres (1996) describes a revolutionary move towards alliances for a majority of research-focused firms that has significantly affected the

significant feature of the business landscape until rather recently. The growth in the value and number of alliances entered into by companies in all industries in the last decade has been tremendous. The pharmaceutical and biotechnology industries have been a particularly good example of this trend, as indicated in Figure 1.[4] By considering the total number of alliance transactions involving pharmaceutical or biotech therapeutic firms over the period 1986-94 we observe that combined, the number of alliances has grown from 166 in 1986 to 492 and 427 in 1993 and 1994, respectively.[5] This contrasts with the fairly level trend for merger and acquisition transactions in the pharmaceutical and biotechnology industries over the same time period (although these transactions have also increased in frequency over the past 18 months).

Because this movement toward strategic alliances and cooperative agreements is comparatively recent, there has been limited empirical research on the impact of these agreements upon firm value within the context of the current industry structure.[6] This contrasts sharply with the wealth of theoretical research on the topic and the several papers investigating "collaborative behavior" generally. In this study, we propose to partially fill this gap in our knowledge about the economic value of these alliances by applying event study estimation to three categories of alliances undertaken by biotechnology firms over the past three years. After confirming that alliances enhance firm value in this industry, we apply cross-sectional analyses to determine the sources of value creation.

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competitive environment. He employs a primarily case-based analysis to carefully examine alliances of large computer firms from the US, Europe, and Japan.

[4] See also Lerner and Merges (1997: Table 2, p. 34).

[5] These aggregate numbers are compiled in Windhover's Information, Inc. (1996).

[6] Particularly noteworthy exceptions are Chan, et al. (1997) and Lerner and Merges (1997), which we discuss in detail in Section 2.

The remainder of this paper is organized into five sections. Section II reviews the relevant literature. Section III discusses our sample selection and summarizes the data that we employ in our analysis. Section IV explains our methodology and Section V presents and discusses our results. The final section provides our conclusions and recommendations for future research.

II. Survey of the Literature

The theoretical literature on strategic alliances is vast and arguably extends back to Arrow (1962), who considers the economic decision to license technology in a manner directly related to the formation of strategic alliances within the context of today's pharmaceutical and biotechnology industries.[7] More recently, Parkhe (1993) provides a good example of an analysis of alliances using a game theoretic framework. In this paper, Parkhe identifies three important attributes of alliances that could logically affect alliance performance. The first attribute is the pattern of payoffs that each of the partners can expect from the alliance. The central importance of payoffs for alliances stems from the requirement that if the net payoff from entering an alliance is not higher than the next best alternative, the profit-maximizing firm has no incentive to undertake the alliance. Additionally, the expected payoffs for an alliance will fluctuate in response to changes in the environment that may alter the pattern of payoffs for each of the respective alliance partners. Two significant regulatory changes that have occurred recently that may affect the payoffs to alliances (and new drug development in the U.S. generally) are a significant reduction in the approval time for NDAs (New Drug Applications) and the allowance of direct-to-consumer (DTC) marketing. The reduction

[7] Lerner and Merges (1997) also identify Arrow's seminal paper as the antecedent of the relevant theoretical literature.

in the length of the drug development process, which is documented in GAO (1995, 1996), has reduced overall development costs. This reduction should decrease the economies of scale in new drug research and development allowing for a greater degree of specialization in the less scale-intensive biotechnology-oriented research. This greater specialization should lead to greater returns for more recent alliances that facilitate this specialization. The new marketing guidelines that facilitate DTC marketing, which includes television advertising, should increase the economies to scale in the marketing of new drug products, thereby increasing incentives for specialized research firms to participate in marketing alliances with larger established drug firms.[8] These fluctuations in expected payoffs may directly affect the optimal structure of alliances.

The second attribute of alliance structure that Parkhe refers to as the "shadow of the future" represents the "bond between the future benefits a firm anticipates and its present actions." In other words, when firms anticipate repeated future interactions they are more likely to cooperate in the present.[9] This is related to the third attribute of alliances that Parkhe emphasizes, "the extent to which the parties perceive each other as behaving opportunistically." He identified partner reputation and the previous alliance history of the respective partners as important attributes that affect the propensity for opportunistic behavior. Parkhe then shows how all of these alliance structural attributes may in turn affect alliance performance.

[8] See Food and Drug Administration (1997) for a summary of the new industry guidelines for DTC advertising.

[9] Game theorists have proven that "iteration improves the prospects for cooperation by encouraging strategies of reciprocity." Parkhe (1993: 799) Parkhe further identifies behavioral transparency, frequency of interaction, and long time horizons as important elements that can promote cooperation by strengthening the "shadow of the future."

To determine the relationship between alliance structure and performance, Parkhe (1993) uses a survey mailed to firm executives involved in managing strategic alliances to measure structure and performance. His empirical findings indicate a weak relationship between alliance performance and his measures of payoffs, a strong positive relationship between alliance performance and transparent behaviors and frequent interaction, and a strong negative relationship with factors associated with an increased propensity for opportunistic behavior.[10] In sum, Parkhe demonstrates that the attributes of a given alliance structure appear to be related to the performance of that alliance.

Other papers that provide additional context for our analysis include Oxley (1997) and Tucci (1996). Similar to Parkhe (1993), these two studies examine the attributes of a variety of alliances (including partner characteristics and collaborative behavior) and hypothesize how these different alliance attributes might affect alliance and firm outcomes. Oxley focuses on the different governance properties of alliances as they relate to appropriability hazards. In particular, she hypothesizes that partner firms choose among alliance types (unilateral contract or simple license, versus a bilateral contract or cross-license, versus an equity joint venture) according to the level of transaction costs. These transaction costs are proportional to the "appropriability hazards" implied by the type of technology transfer which the firms are attempting to conduct through their alliance. Oxley examines 165 alliances between U.S.-based manufacturing firms over the period 1980-89. She concludes, "firm-level effects do not have statistically significant effects," and infers that this result is consistent with

[10] Parkhe suggests that his counterintuitive result of a weak relationship between payoffs and alliance structure may be due to measurement error of payoffs in his empirical analysis.

transaction cost theory, which emphasizes the “attributes of the transaction (i.e., the project), and not those of the firm as a whole” for determining the preferred mode of governance for the alliance.

Instead of U.S. alliances, Tucci (1996) addresses international technology alliances (his dataset consists of surveys from 125 European R&D managers). He attempts to answer the question “to what extent do partner characteristics and collaborative behavior influence performance outcomes of strategic technology alliances?” Specifically, he identifies market overlap between the partners as a negative influence on alliance outcomes, and technical and social overlap between the partners as positive influences. His measure for alliance outcomes derives from an Internet survey conducted among European technology firms. His conclusions indicate that “it is very difficult to successfully manage horizontal technology alliances . . . (Tucci, 1996: 29).”

Pisano (1989) has conducted a related analysis. Pisano (1989: 109) examines “the motives for using partial equity investments in collaborative relationships.” Employing the transaction cost approach of institutional economics he concludes “partial ownership [through direct equity participation] has advantages in collaboration where parties must make transaction-specific investments under conditions of uncertainty Pisano (1989: 114)." This result, like Oxley (1997), is consistent with transaction cost theory.

The performance data that these authors employ generally derive from self-reported survey data or subjective observations of alliance outcomes. Additionally, rather than focusing on quantitative measures of alliance outcomes, these previous studies have focused on alliance governance (Oxley (1997) and Pisano (1989)). One recent study, however, conducts an objective empirical analysis of strategic alliances. Chan et al.

(1997) [hereafter CKKM] investigate share price responses to the announcement of 345 strategic alliances over the period 1983-92 in a variety of industries.[11] One of their important findings is that "establishing strategic relationships creates significant value for the shareholders of the partnering firms (CKKM: 209)." In comparison to McConnell and Nantell (1985) [hereafter M&N], who find a 1.10% excess return for small firms and 0.63% for larger firms involved in joint ventures, CKKM find an excess return of 2.22% for smaller firms and a statistically insignificant 0.19% for larger firms involved in strategic alliances. Both CKKM and M&N conclude that the creation of strategic alliances and joint ventures, respectively, are responsible for significant wealth gains. Additionally, both CKKM and M&N convert their findings into dollar values, estimating average gains of $8.9 million and $8.1 million for the smaller and larger firms, respectively, in strategic alliances and $4.5 million and $6.6 million for the small and large firms involved in joint ventures.[12] To determine the possible sources of these gains, CKKM investigate cross-sectional differences in excess returns and find that in general, horizontal alliances (those between firms in the same SIC class) result in significantly higher abnormal returns than non-horizontal alliances.[13] Additionally, alliances that were formed for the purpose of transferring or "pooling complementary technological knowledge and skills" tended to result in greater value creation.[14]

[11] For a distribution of industry affiliation for each of the alliances included in their analysis, see Table 2 on p. 207. Their sample covers 20 distinct industries, with the vast majority of the sample classified within the "Computers, information technology, and software" industry. This single industry category represents close to 60% of their entire sample.
[12] Note that the M&N sample contains 136 joint ventures over the period 1972-79, while the CKKM sample contains 345 strategic alliances over the period 1983-92, so that corrections for inflation would make the wealth gains for each group of transactions very nearly equal in absolute terms.
[13] It is interesting to note that this result contrasts with the Berg and Friedman (1981) analysis of domestic joint ventures which finds that horizontal joint ventures actually result in a reduction in the rates of return for the participant firms.
[14] See the discussion in (CKKM, 1997:213) and Table 4 on page 221.

Due to the significant heterogeneity of the CKKM sample, however, the sources of value creation are difficult to identify.[15] In an analysis of biotechnology collaborations, Lerner and Merges (1997:2) [L&M] empirically examine "how control rights are assigned in one particular environment: agreements to research and develop new products and processes between biotechnology firms and either pharmaceutical or larger biotechnology companies." In their analysis, they test the validity of the model presented by Aghion and Tirole (1994) which predicts that the allocation of property rights in alliances will depend on two factors. These two factors are the extent to which underinvestment by either or both of the parties jeopardize the success of the project and the relative bargaining power of the two parties (L&M: 2). L&M use three case studies and the database maintained by Recombinant Capital, which contains detailed information about partnerships between biotechnology companies and universities, research centers, other biotechnology firms, and pharmaceutical firms.[16] The two primary results from their analysis are: 1) There is a statistically significant negative relationship between the number of control rights allocated to the larger firm and the financial strength of the smaller firm and 2) Alliances in the early stages of a project tend to allocate more, not fewer, control rights to the firm financing the R&D (L&M: 23,25). They conclude that their first result is consistent with the Aghion and Tirole (1994) model, but that their second result is not easily interpretable within the context of that model. These results are relevant for the analysis of this paper, because they

[15] CKK M does find that for horizontal alliances (involving partner firms in similar industries), "more value accrues when the alliance involves the transfer or pooling of technical knowledge than with nontechnical alliances." This result is consistent with the findings of Berg and Friedman (1980) for joint ventures facilitating technological knowledge transfers.

[16] The three case studies which L&M include in their analysis are: 1) The 1978 alliance between ALZA and Ciba-Geigy which ceded significant control over ALZA's research projects to Ciba-Geigy, 2) The

suggest important factors that might affect the wealth gains from alliance formation in the biotechnology industry.

In this study, we combine the predictions of earlier papers about the relationship between alliance structure and firm performance with the quantitative firm performance measures employed in CKKM. In addition, we add alliance partner characteristics, and alliance partner performance prior to alliance participation to a focused analysis of the biopharmaceutical industry. Because of our single industry focus, we are able to examine several structure-performance-partner characteristic relationships within alliances, which have not been previously considered. Table 2 provides a summary of the relevant empirical research to place our analysis in context.

III. Data

The sample for this paper derives from the Recombinant Capital (ReCap) compilation of alliances among pharmaceutical and biotechnology firms over the relatively recent period June 1995 through June 1997.[17] The definition for alliances we use is: "any governance structure involving an incomplete contract between separate firms and in which each partner has limited control (Gomes-Casseres, 1996:34)."[18] Our alliances all consist of two firms.[19] One firm (generally a larger pharmaceutical or biotechnology firm) is considered the client partner, while the other firm (generally a smaller biotechnology

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ImmuLogic Pharmaceutical Corporation alliance with Marion Merrell Dow in 1991, and 3) The highly successful Repligen Corporation and Eli Lilly alliance completed in May 1992.

[17] See http:\\www.recap.com\.

[18] Alternatively, Parkhe (1991: 581) proposes the following description of strategic alliances, "relatively enduring interfirm cooperative arrangements, involving flows and linkages that utilize resources and/or governance structures from autonomous organizations, for the joint accomplishment of individual goals linked to the corporate mission of each sponsoring firm."

[19] Multifirm alliances are of separate interest and are discussed by Gomes-Casseres (1996) within the context of the computer hardware industry. A brief perusal of the available data suggests that the vast

firm focused on discovery efforts) is classified as the R&D partner. The dates for our dataset were selected to homogenize our observations as much as possible and to allow for a valid comparison of the major categories of biotech alliances that we identify in our analysis. In particular, we employ the following categories for the alliances in our dataset: 1) research agreements, 2) development agreements, and 3) marketing agreements. These categories account for only a subset of the thirty-one categories employed by ReCap, but they capture the majority of partnerships, which we would classify as strategic alliances as opposed to acquisitions, asset purchases, or joint ventures.[20]

We obtained the initial data on these various alliances from the Recombinant Capital (ReCap) database of strategic alliances.[21] We have employed detailed descriptions of firm operations from industry newsletters such as ***Biotechnology*** and ***BioNature*** and, when available, annual reports to confirm our categorization of the alliances. Additionally, we have obtained publicly released statements which are referenced in the ReCap database to confirm the precise announcement dates for each of our alliances. When these statements were not available through ReCap, we obtained them from other published press reports. All of these company press releases were corroborated with publicly available press reports from the financial press, such as the ***Wall Street Journal***. The stock-return data employed in the event studies is derived from the CRSP

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majority (> 80%) of alliances in the biopharmaceutical industry are of the two partner variety, although this has changed recently. We plan to address this special category in a future study.

[20] The ReCap database provides a comprehensive compilation of a variety of transactions relevant for the biotechnology and pharmaceutical industries. They include acquisitions, asset purchases, joint ventures, as well as agreements completed between companies and universities. Since our focus is upon strategic alliances, we excluded a majority of the transactions, which we could not classify as multifirm agreements. Future research should analyze in greater detail variations across the various forms of partnership across categories to include acquisitions and joint ventures.

tapes. In our cross-sectional analysis, we employ data available from SEC-filings and the COMPUSTAT database. This data includes revenues, total assets, number of employees, and R&D expenses to measure firm size (in addition to firm market capitalization) and firm commitment to R&D. From these sources, we are able to compile a comprehensive picture of the biotechnology and pharmaceutical firms involved in strategic alliances.

Since our period of analysis is focused on the three-year period 1995-97, several of the firms in our sample have been involved in multiple alliances. For the 123 alliances in our sample, we would have 246 possible participants, if all of our alliances consisted of unique firms. In fact, we have 135 firms in our sample, with the mean number of alliances per firm at just fewer than two. The three firms with the most alliances in our sample, with ten apiece, are Genentech, SmithKline Beecham, and Schering-Plough. Eighty-eight of the firms in our sample are represented with only one alliance in the sample.

Our sample of alliances was reduced from the universe of total alliances for several reasons. The first criterion to confirm with transactions derived from Recap is the type of transaction. Starting with all recorded transactions from January 1, 1995, through July 30, 1997, we begin with approximately 1,400 observations. Half of these observations, however, are non-alliance agreements, such as asset purchases, acquisitions, joint ventures, etc. An additional 200 observations are transactions concluded with university or other nonprofit research organizations. These observations were also eliminated from our sample. In many cases, one or both of the firms were not publicly traded. Since

[21] For a detailed introduction to this and related databases constructed by Recombinant Capital see the following web site: www.recap.com.

foreign firms must deal with different legal requirements we omit them as well, so as not to complicate the data gathering for now.[22] Two final criteria that we employ to restrict our sample are 1) when significant additional events affect partner companies concurrent with the alliance announcement, 2) insufficient trading days. The criteria for our sample and the approximate number of observations that were eliminated for the various reasons are given in Table 3. Table 4 lists the 123 alliances in our final sample.

For our cross-sectional analysis we model the share price response as a function of firm and alliance characteristics. In particular, we employ the following equation: Δfirm i's share price of R&D firms in the sample = f (client firm size, R&D firm size, client firm R&D intensity, client firm profitability, R&D firm profitability, license indicator, equity indicator, complex disease indicator, early stage indicator, alliance type indicator, year indicator, and four interaction terms). As with any such analysis, the firms and the alliances that we examine are quite heterogeneous. We have attempted to minimize this heterogeneity by focusing on research-intensive pharmaceutical and biotechnology firms.

The first variables that we include in our model are measures of size for the partner firms. These are market capitalization, total assets, and net sales.[23] Firm size variables have been included in previous analyses as control variables. For our analysis of the source of value creation, as exhibited by share price response, we control for the size of the alliance partners since larger firms may exhibit a smaller percentage reaction to the transaction announcement than the smaller partner firms simply because of their

[22] We plan on returning to this issue in a subsequent paper focusing on a comparative analysis of domestic versus international biopharmaceutical alliances.

greater size. Additionally, firm size may be correlated with alliance value directly for a variety of reasons. Larger firm size, for example, may be positively correlated with a firm's ability to appropriate gains from the product development that may result from a research or development alliance. Such a correlation would result in higher cumulative abnormal returns for larger client firms.

The second firm-specific variable that we include in our analysis, is R&D intensity. Following CKKM, alliances created for the purpose of exploiting complementarities in research and new product development may on average create more value than other alliances. Such alliances should benefit by having more research-intensive partner firms. Cohen and Levinthal (1989) provide one justification for this reasoning. They demonstrate that for firms to extract value from innovations completed external to their own R&D activities they must possess "absorptive capacity." This is the ability to exploit unfamiliar technology. Within this context, such ability might be relevant for the client firm. Higher R&D-intensity for the client firm may therefore be positively correlated with value creation as a result of this capability.

The third firm variable that we include is a measure of firm performance. Since we have sales variables up to several years prior to each of our alliance announcements, we can determine performance characteristics of the partner firms such as sales growth prior to alliance participation. We have also included net income and total stock returns for each of the partner firms during the one-year period prior to the thirty days before the alliance announcement as alternative firm performance measures. Partner performance measures prior to an alliance are possibly relevant to an alliance outcome for two

[23] To prevent the alliances from influencing the market capitalization of each of the participating firms, which we use for the second part of our analysis, we take the market capitalization of each firm 30 days

reasons. First, if a partner firm has been performing well prior to an alliance announcement then it may be the case that its negotiating leverage over alliance provisions is strengthened. This may be correlated with a stronger positive response to an alliance announcement. By contrast, strong prior performance may also indicate that an alliance may be unnecessary for the realization of good future performance, so that a negative response may follow an alliance announcement. Consistent with this view is the perception that a well-performing firm that announces an alliance may be signaling a previously concealed weakness.[24] Note also that from the perspective of the R&D firm, prior strong client firm performance may also serve to reduce the gains from an alliance transaction to the R&D firm due to the client firm's enhanced bargaining position vis-à-vis the R&D firm. There are thus several empirical possibilities that may result from our cross-sectional analysis with regard to prior partner firm performance. The three possibilities are: 1) it may serve to enhance the overall market valuation of the research being undertaken by the partner firms, 2) it may serve to extract greater gain for the client firm at the expense of the R&D firm, thereby diminishing the beneficial response for the R&D firm which may in turn lead to a lower assessment of the alliance, or 3) the alliance may be perceived as a signal of previously unrevealed weaknesses on the part of the R&D firm, at least when it comes to attracting the necessary capital and/or resources for conducting independent R&D. On balance, stronger client firm performance may lead to lower value creation and stronger R&D firm performance may lead to either higher or lower value creation. Whether either is the case, however, is an empirical question.

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prior to each of the event windows.

The alliance-specific variables include indicator variables for whether the alliance includes equity participation (***equity)***, involves a licensing agreement ***(license)***, a product to treat a complex disease (***complex disease***), is made at the early stage of R&D (***early stage***), or involves a research (***research***) or marketing and development (***marketing agreement***).[25] As demonstrated by Pisano (1989), equity linkages serve to align partner incentives when alliances are characterized by uncertainty and transaction-specific capital. The alliances that we consider in our analysis most likely contain significant levels of both uncertainty and transaction-specific capital, and should therefore benefit from equity participation among alliance partners. Improved partner incentive alignment due to equity linkages may in turn result in greater value creation. This reasoning leads us to the expectation that equity participation among alliance partners will be positively correlated with the level of value creation resulting from the alliance.

The next alliance attribute that we control for and for which we have complete sample representation is an indicator of a license provision within the alliance. This provision is important from a property rights perspective. Partner firms involved in drug alliances are often times involved in complex technology transfer. Given this complexity, it may be the case that when firms are able to agree on a license provision, that the technology being transferred is sufficiently well specified to allow a greater degree of explicit contracting. These more explicit contracts might assign some of the relevant property rights, which could serve as a positive signal to external observers of the structure of the alliance.

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[24] This line of thinking is consistent with the findings by Mohanram and Nanda (1996), which conclude "Firms enter into joint ventures when their performance is deteriorating."

[25] In addition to these alliance attributes we also have the size of the deal, which represents up-front payments made by the client firm to the R&D firm at the beginning of the alliance. This deal size variable, however, is only available for 55 of our 123 alliances due to the common industry practice of redacting this information from their publicly available announcements and filings. Because of its sparse availability we did not include it in our final analysis.

Alliances with licensing provisions may therefore, exhibit greater value creation than alliances that do not contain such provisions.

The next two alliance attribute variables that we include in our model, are an indicator for complex diseases and an indicator for early stage alliances. Including these two attributes in our model is consistent with the predictions of the transaction cost literature for contracts involving technology transfer. The more difficult it is to define the technology that a new alliance is designed to develop, the higher will be the transaction costs for completing the alliance.[26] In particular, the contractibility of alliances involving complex diseases is most likely lower than alliances designed to address less complex diseases.[27] As shown in Nelson and Winter (1977) the greater the level of uncertainty affecting a process, the more difficult it will be to write contracts to effectively govern that process. Arguably, alliances over complex diseases feature higher levels of uncertainty. As such, alliances involving complex disease categories may be associated with lower value creation.

Similarly, alliances involving early stage research or products should also correlate with lower net value creation due to the higher transactional costs and greater uncertainty which are inherent in such alliances. According to L&M, “Since most biotechnology firms have expertise in early-stage research, we anticipate that many more control rights would flow to them in the early stages of the project.” This suggests that for alliances consummated for early stage research projects, the abnormal returns accruing to the R&D firm should be higher, ceteris paribus. Interestingly, L&M find that

[26] See Williamson (1985: 292-294). In particular, see his discussion on page 293 explaining that “Attempts to transfer technology by contract can break down because of the ‘paradox of information.’”

early-stage alliances are characterized by a greater degree of control rights allocated to the sponsoring or client partner firm. An alternative interpretation of this result is that early-stage projects are characterized by greater risk. To adequately compensate the investor for this greater risk, the R&D firms most forgo a greater proportion of their claims to the future revenue streams from the research project.[28] Myers and Howe (1996) estimate the risk of cancellation as particularly high for the early stages of new drug research. They attribute the high cost of capital for biotechnology firms, as observed by their higher market betas, to this higher risk.[29] From a cost-of-capital perspective, then, earlier stage alliances may result in lower abnormal returns for the R&D partners.

The final attribute of alliances that we consider in our analysis is the type of agreement. According to CKKM, greater value accrues to technical alliances that involve technology transfer, as opposed to nontechnical alliances such as marketing alliances.[30] Hagedoorn and Schakenraad (1994) define this technical alliance category as follows, "Strategic technology partnering is the establishment of cooperative agreements aimed at joint innovative efforts or technology transfer that can have a lasting effect on the product-market positioning of participating companies." In this light, given the importance of new product development for drug firms, we might expect that

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[27] Note that we group diseases such as AIDS, cancer, central nervous system afflictions (excluding depression), and cardiovascular illnesses into a complex disease category. Other diseases that deal with ophthalmic, dermatological or metabolic afflictions fall into the noncomplex disease category.

[28] Note that we classify alliances for products that have not completed Phase II clinical trials or earlier as early-stage alliances. This includes alliances created for the purposes of new product discovery, lead molecule formulation, pre-clinical trials, or the completion of Phase I trials.

[29] In a related research paper, Myers and Shyam-Sunder (1996) estimate that biotechnology firms have a 33% higher cost-of-capital relative to the larger pharmaceutical firms. See Tables 10-4 and 10-5 on pp. 223 and 228.

[30] In particular, they find that for horizontal alliances, technical alliances involving the transfer or pooling of technology, abnormal returns average 3.54% versus 1.00% for nontechnical or marketing alliances. See

greater value should accrue to alliances focused on research and development (the creation of new products) over marketing alliances (the distribution of new products or creating demand for new products).

From another perspective, however, marketing is a particularly important activity for the pharmaceutical industry. To confirm the importance of marketing in this industry we collected data to compute the advertising to sales ratios for the top fourteen firms in the pharmaceutical industry in terms of market capitalization over the years 1991-96.[31] For the fifty-nine firm-years of data that we collected, we compared R&D-to-sales ratios versus advertising-to-sales ratios and found that for fourteen of the firm-years (25% of the sample) the advertising-to-sales ratio actually exceeded the R&D-to-sales ratio. This empirical finding suggests that marketing is a very important activity among the top pharmaceutical firms. Marketing alliances, therefore, may not be significantly less valuable than research and development alliances for this industry. We test these contradictory predictions in our cross-sectional analysis by including controls for each of our three alliance categories.

We also include several interaction terms in our analysis. In particular, the interaction between research and development agreements and equity participation, the interaction between marketing agreements and licensing, the interaction between early stage agreements and equity participation, and the interaction between complex diseases and equity and licensing. The justification for our interaction term between our equity indicator and our indicators for research and development alliances comes from the

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Table 4. They are not, however able to "distinguish between the value contributions of alliances based on whether the transaction involves more versus less transaction-specific knowledge (CKKM : 213)."

conventional industry wisdom that equity participation is relatively more important for alliances involving more complex activities such as research and development to align partner incentives.[32] Similar reasoning applies to early stage and complex disease alliances. We may therefore expect that research and development alliances, and early stage and complex disease alliances with equity participation will create greater value than the same types of alliances without equity participation. Licenses are more important for facilitating technology transfer in later stage alliances such as marketing alliances. Marketing alliances formalized with licensing agreements, therefore, may be more effective than such alliances without licensing provisions.

The final variable we include in our analysis is a control for the year of the alliance, ***year97***. Given the history of alliances in this industry over the past decade, it may be that case that substantial learning has occurred with regard to the most appropriate manner to complete these complicated transactions. If this has been the case, then more recent alliances may be more valuable. We use an indicator variable showing our most recent alliances in 1997.[33] We summarize our data and the expected effects of our variables upon alliance value creation in Table 5. We now turn to our specific methodology.

IV. Methodology

We proceed in two parts. First, we determine the level of value creation attributable to the creation of the alliances we examine. In this analysis, we employ an event study

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[31] The fourteen firms are: Abbott Laboratories, American Home Products Corp, Bristol Myers Squibb, Glaxo Wellcome PLC, Hoechst Marion Roussel, Johnson & Johnson, Eli Lilly, Merck, Pfizer, Pharmacia & Upjohn, Rhone-Poulenc Rorer, Schering-Plough, SmithKline Beecham, PLC, and Warner-Lambert Co.
[32] Pisano (1989) also strongly supports the inclusion of such an interaction term.
[33] Using a dummy variable for 1997 alliances almost bisects our sample. Our 1997 alliances comprise close to 44% of our sample.

model patterned after MacKinlay (1997). We use the following market model to predict the expected return for a firm in our dataset:

$$E[R_{it}] = \alpha_i + \beta_i (M_t) + \varepsilon_{it}$$

where R_{it} is the rate of return for security i at time t and M_t represents the market return at time t (such as the NASDAQ composite index or the CRSP Value-Weighted Index).[34] This model gives us a predicted rate of return, $\hat{R}_{it}$, to compare to the rate of return which actually obtains for our sample firms, R_{it}. This allows us to compute abnormal returns $AR_{it} = R_{it} - \hat{R}_{it}$ that result from the creation of each of the alliances in our sample. We apply this model to our sample of 123 alliances. This provides us with a sample of abnormal return estimates, which we aggregate over several different event windows (3-day, 11-day, and 21-day) to arrive at cumulative abnormal return estimates for both partnering firms and a combined cumulative abnormal return for each alliance.[35] We estimate our model using a variety of market indices, but conclude that the CRSP Value-weighted index is the preferred market index.[36] In the second part, we employ these cumulative abnormal returns in a cross-sectional analysis so that we may identify the most important factors that influence the level of value creation attributable to alliance creation in this industry. In particular, we investigate which firm and alliance

[34] All returns in our estimation are net of the risk-free rate of return as represented by the three-month U.S. Treasury Bill.
[35] Note that we also used the following asymmetric event windows (-20, +5), (-10, +3), (-5, +1) obtaining similar results.
[36] In particular, we estimated our CAPM equation using the industry index by itself, the market index by itself, and both indices combined, and attained the highest adjusted R-square by using the market index by itself.

characteristics are the most important in determining cumulative abnormal returns. The primary specification for this analysis is:

$$CAR_i = \alpha_i + \beta_1 \text{MktCap R\&D} + \beta_2(\text{MktCap R\&D})^2 + \beta_3 \text{MktCap Client} + \beta_4(\text{MktCap Client})^2 + \beta_5 \text{R\&D Intensity-Client} + \beta_6 \text{Total Return Client} + \beta_7 \text{Total Return R\&D} + \beta_8 \text{Equity} + \beta_9 \text{License} + \beta_{10} \text{Early Stage} + \beta_{11} \text{Complex} + \beta_{12} \text{Research} + \beta_{13} \text{Development} + \beta_{14} \text{MktCap Client} * \text{Research} + [\text{in alternative specifications}]\ \beta_{15} \text{Equity} * \text{Research or } \beta_{16} \text{License} * \text{Research} + \beta_{17} \text{Year '97} + \varepsilon_i$$

where i = R&D firm, client firm

MtkCap R&D = the capitalization of the R&D firm to include a quadratic term[37]

MktCap Client = the capitalization of the Client firm to include a quadratic term

R&D Intensity Client = the R&D intensity of the Client firm

Total Return Client = the total stock return for the Client firm prior to the alliance announcement[38]

Total Return R&D Firm = the total stock return for the R&D firm prior to the alliance announcement

Equity = an indicator for alliances which include equity participation by the Client firm

License = an indicator for alliances which include a license of technology

Early Stage = an indicator for alliances involving research or products earlier than Phase II

Complex = an indicator for alliances involving a complex disease

Research = an indicator for research alliances

Development = an indicator for development alliances[39]

[37] Alternative measures that we also include in our analysis are net sales and total assets.
[38] Alternative measures for firm performance that we also include are net income and sales growth.
[39] Note that the indicator for marketing alliances is omitted, so that the interpretation of our coefficient estimates for the research and development alliance indicators will be in relation to marketing alliances.

Interaction Terms = include interaction between client market capitalization * research agreement, equity indicator * research agreement, license indicator * research agreement in separate specifications

Year '97 = indicator for alliances announced in 1997, roughly 44% of the sample.

We report the results for the various specifications in the next section and discuss their implications.

V. Results

The first set of results we obtain involve our estimated cumulative abnormal returns for the R&D and client firms. As indicated above, we consider three possible event windows to ensure that we are not mismeasuring the abnormal returns due to our events of interest, in this case alliance announcements. The data suggest that a narrower event window is more appropriate for our sample, because unlike in large mergers and acquisitions, there appears to be little or no leakage prior to our event announcements. Additionally, since pharmaceutical and biotechnology firms tend to make announcements that materially affect their value at frequent intervals a shorter window is necessary to minimize the noise from unrelated announcements.[40] Table 6A shows our results for our R&D firms and our client firms across the three event windows. As indicated for the R&D firms in our sample, the three-day event window yields the most conclusive results. Value creation (or cumulative abnormal returns, CAR) for these firms averages 4.4% over the event window. [41] For the client firms, the results indicate an average .37% CAR. When we aggregate our observations across all

[40] Ravenscraft and Long (1997) observe that "Announcements concerning new drug discoveries, regulatory changes, legal matters, alliances and individual drug cash flow projections are common." This suggests that the best measure of stock market reaction requires "fairly narrow windows." See page 14.
[41] The 5% and 10% trimmed means for the R&D firms' CAR are also statistically significant at 3.5% and 3.1%, respectively.

123 alliances, we obtain very strong t-statistics for the R&D firms, 10.04 using the three-day event window and an insignificant t-statistic for the client firms of only 1.25. Due to the relatively skewed distribution of CARs, we also report the median values in Table 6B, of 2.3% for the R&D firms and .14% for the client firms. In sum, the R&D firms do very well in these alliances in percentage terms while we cannot draw substantive conclusions regarding the benefit to the client firms.

Our results in dollar value terms are slightly different due the significant size asymmetry between the client and R&D firms. The dollar value gains for our R&D firms average $21.4 million (with a median value of $4.2 million). The dollar value gains for our much larger client firms average $149.4 million (with a median value of $3.5 million). The combined dollar gain for our alliances average $170.8 million (with a median value of ($10.1 million). We must caveat these results, however, with the fact that only R&D firm gains are statistically significant.

These results are generally consistent with CKKM and M&N in several ways. The smaller partner experiences the greater and statistically significant percentage gains, while the larger partner experiences an insignificant but possibly equivalent or larger dollar gain. Our resulting value gains appear to have a greater variance than either the CKKM or M&N analyses and appear to be slightly more asymmetric. This may be due to our sample's greater size asymmetry. In CKKM's strategic alliance analysis, the larger partners are ten times larger while in M&N's joint venture analysis; the multiple is only five. Our market capitalization ratio of client to R&D firms is twenty to one.[42] This asymmetry in market capitalization may be related to our asymmetry in value creation

[42] Note also that although the mean for the market capitalization for our R&D firms is $1.35 billion, this represents a very skewed distribution. The median market capitalization is only $181 million.

for R&D firms versus client firms. Table 7 summarizes the findings of the three related industry-specific analyses along with our results.[43]

An interesting contrast between our findings and the M&N and CKKM findings is the greater value creation that results from the transactions in our sample. Our dollar-value creation amounts are on average greater than the CKKM findings on strategic alliances across twenty different industries (adjusting for inflation), and also greater than the M&N findings across several industries. This finding is consistent with the claim by CKKM that horizontal, technical alliances provide significant opportunities for value creation, since the alliances in our analysis are clearly horizontal, technical alliances. Unfortunately, the imprecise estimates of effects for client firms, which are not statistically distinguishable from zero, precludes any further analysis of the distribution of wealth gains from alliances between R&D and client firms.

The second stage of analysis models the heterogeneity of returns across firms and alliances. As Figure 2 demonstrates, the averages mask considerable variation in the estimated abnormal returns around alliance announcement dates. Table 8 presents results from the cross-sectional analysis of alliance returns for the R&D firms. We estimate variants of the cross-sectional equation specified in the previous section and present the results in this table. Note that our dependent variable for this analysis is the CAR for the R&D firm.[44] The remainder of this section focuses on the CAR for our R&D firms as the dependent variable.

[43] We believe that the analysis recently conducted by Ravenscraft and Long (1997) of 65 pharmaceutical mergers is also relevant here for perspective, because it represents another related category of transactions within the same industry. They find CARs of 13.31% and –2.12% for their targets and bidders, leading to a combined dollar value creation of $289 million.

[44] We have performed the same exercise for the returns to client firms, but not surprisingly, find little explanatory power for the model.

Model one includes a quadratic for the market capitalization of the R&D firm and the client firm. Model two includes only the firm market capitalization of the R&D firm. In a variety of specifications employing market capitalization along with alternative measures of firm size such as total net sales, total assets, and R&D expenditures for ***both*** the R&D and client firms, we never encounter even a marginally significant coefficient.[45] Our results for models one and two are presented in the first two columns of Table 8. These results are consistent with Oxley (1997), who also finds that firm characteristics have insignificant effects upon alliance governance choice.

Unlike the partner firm characteristics, several of the alliance attribute measures are significant in our cross-sectional analysis. Our equity, complex disease, and time trend indictor variables all enter significantly and with the expected sign for each of initial model specifications. Alliances that include equity participation average seven percentage points greater returns (standard error, two percentage points) than alliances without equity participation. Whether this reflects the fact that firms choose to take equity participation in the alliances with the greatest expected value, or a causal effect of equity participation on expected success is beyond the scope of this paper. Our coefficient estimates for our license indicators are essentially zero. This result fails to provide support for our hypothesis that licenses are important for facilitating technology transfer in these alliances.

In addition to our equity indicator estimates, the coefficient estimates for our complex disease indicator enters negatively at close to -.06. This result is consistent with our reasoning above for alliances involving complex diseases. The difficulties associated

[45] In particular, all coefficient estimates are close to zero with relatively large standard errors.

with coordinating separate company efforts to address the more difficult targets is reflected in lower value creation for these alliances.

The early stage indicator enters negatively as hypothesized with a point estimate of -.04, but is not quite statistically significant in our first two specifications with an average p-value of just over .10. Our research alliance indicator enters positively at .04, but is not statistically significant. Our indicator for development agreements enters positively at .03, but is also not statistically significant. These results are inconsistent with CKKM's finding that research and development alliances provide significantly greater opportunities for value creation than comparable marketing alliances, but because of the industry-specific nature of our sample these results are not surprising results. Specifically, biotech firms engage in intensive specialization and large drug firms place significant emphasis upon marketing. Given the apparent importance of marketing in our industry of analysis, it may very well be the case that marketing alliances in the industry are just as important for revenue generation as research and development alliances, unlike in other industries.

In Model 3, we add total return for the R&D and client firms to our specification. The client firm return is insignificant, but the R&D firm return enters with a negative coefficient of -.03 and is statistically significant at the 1% level. Adding this variable also increases the explanatory power of our overall model as suggested by the increased adjusted R-square. None of our other performance measures such as sales growth or net income yields significant coefficients. This result suggests that an R&D firm that is experiencing strong total returns prior to an alliance event will receive lower gains from an alliance announcement than an R&D firm that had been experiencing weak total

returns. If we recall our argument about research project or new product value signaling, this result makes sense. The alliance announcement serves as a more positive signal for previously weak performers than it does for firms that are already doing well without the alliance.

In model 4 we add three interaction terms, R&D alliance*equity, early stage*equity, and complex disease*equity. All three terms enter significantly. Research and development alliances that include equity participation create greater value than such alliances, which do not include equity participation. Our other two interaction terms enter negatively suggesting that early stage and complex disease alliances with equity participation create significantly less value than other alliances involving equity participation. In model 5 we consider an interaction term between our marketing alliances indicator and the license indicator and find no discernible effect.

In the final model presented in Table 8, we drop the irrelevant firm characteristics. With alliance characteristics alone, the return to the R&D firm, and our equity interaction terms, we are able to achieve significant explanatory power as suggested by our adjusted R-square of .24.

Based on our part two cross-sectional analysis we can draw the following conclusions: 1) Equity participation is a significant feature of strategic alliances in the biopharmaceutical industry characterizing alliances resulting in the greatest value creation. 2) Licensing provisions are not as important as one might expect for technical alliances. These two results are robust to model specification. 3) It is more difficult to realize positive value creation for alliances targeting complex diseases. In fact, partners completing complex disease alliances realize significantly less value than partners

involved in noncomplex disease alliances. 4) Research and development alliances do not appear to yield significantly greater value creation relative to marketing alliances in this industry. 5) The market capitalization of neither the client firm nor the R&D firm appears to significantly affect the realization of gains by the R&D firm.

VI. Conclusions and Recommendations for Future Research

From the first part of our analysis we draw the following conclusions: 1) Alliances between pharmaceutical and biotechnology firms create significant value for the R&D firm. We cannot, however, discern any significant value creation for the client firm, as evidenced by our event study analysis of 123 alliances. 2) In particular, R&D firms experience a higher percentage gain, averaging 4.40%, while client firms gain on average a statistically insignificant .39%. 3) In dollar terms, the R&D firms experience a mean level of value creation of $18 million. 4) In absolute terms, the total value gains from alliances in this industry are significantly larger than the average gains for the alliances considered in CKKM, which is consistent with their proposition that horizontal, technical alliances provide the best opportunities for value creation.

From the second part of our analysis, alliance characteristics appear to be much more important than firm characteristics for explaining the value gains that accrue to the R&D firms involved in the biopharmaceutical alliances. In particular, we find corroboration for Pisano's (1989) results regarding the importance of equity for R&D alliances. Also, consistent with the general predictions of CKKM, it may be the case that because the alliances in our sample are horizontal, technical alliances, they create value that on average exceeds the value gain of the CKKM sample of alliances. We also find results consistent with Lerner and Merges (1997) regarding early stage

alliances, in that R&D firms do not benefit as clearly from such alliances as their client firm partners. More importantly we confirm the importance of equity participation versus licensing provisions for alliances. We recommend that for future research, careful analyses of more homogeneous samples of alliances such as the one we examine here, will allow us to more clearly examine the sources of value creation from these increasingly prevalent interfirm transactions.

Table 1. Ten U.S. Companies with the Most Alliances from 1990-96

Company	Alliances	Annualized Shareholder Return (%)
Dow Chemical	142	5.4
Intel	130	32.6
Ford	127	16.2
Oracle	111	77.8
Westinghouse	107	-15.7
Bristol-Myers Squibb	***98***	**6.9**
Bell Atlantic	98	3.5
Eli Lilly	**94**	**3.8**
MCI	88	7.5
Merck	***86***	**16.8**

Source: Alliance Analyst (1997).