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THE IMPACT OF GENERAL AND PARTNER-SPECIFIC ALLIANCE EXPERIENCE ON JOINT R&D PROJECT PERFORMANCE

Abstract

We study the impact of firm-level general alliance experience and partner-specific, dyad-level alliance experience on joint R&D project performance. We leverage a unique dataset that captures performance at the project level between large pharmaceutical firms that are attempting to leverage the new biotechnology, and their partner organizations. We find that the general alliance experience of the biotechnology partner appears to be critical to collaborative success and partner-specific experience was not significant for subsequent alliance performance.

Key words: Learning within and across alliances; project-level analysis; alliance performance; pharmaceutical industry

Running header: General and partner-specific alliance experience

INTRODUCTION

Strategic alliances are voluntary arrangements between firms to exchange and share knowledge with the intent to develop processes, products, or services (Gulati, 1998: 293). Alliances have become an important corporate-level strategy as evidenced by their ubiquitous use across many different industries. Hagedoorn (1993), for example, tracked almost 10,000 technology cooperations involving some 3,500 companies. Recently, Anand and Khanna (2000) reported that more than 20,000 alliances were formed over a two year time period. While alliances appear to be an important organizational form that is used extensively, researchers have also produced evidence suggesting that many, if not most, alliances do not live up to expectations or even fail altogether (Harrigan, 1986; Kogut, 1989; Bleeke & Ernst, 1993). Understanding the performance of individual alliances is an important, yet under researched, topic in strategic management (Gulati, 1998).

Despite its importance, empirical work in this area is scarce largely due to methodological barriers (Anderson, 1990; Gulati, 1998). Information on alliance performance is difficult to obtain and, while alliance performance is a *joint outcome*, it has not been linked to characteristics of all the partners involved in an alliance. Early studies have equated alliance termination with alliance failure (Beamish, 1985; Harrigan, 1986; Kogut, 1989; Levinthal & Fichman, 1988), but termination may be a consequence of partners having successfully reached their objectives, or it may be a pre-planned event. More recently, scholars have proxied collaborative performance by the longevity of joint ventures (Barkema, Shenkar, Vermeulen, & Bell, 1997). Others have resorted to perceptual measures of alliance performance by one of the partners in the alliance (Parkhe, 1993; Zollo, Reuer, & Singh, 2002) or equated alliance performance to the reaction of the stock market to alliance announcements (Anand & Khanna, 2000; Merchant & Schendel, 2000).

In this paper, we seek to make a theoretical as well as a methodological contribution to our understanding of alliance performance. In building on recent work that documented performance benefits from alliance experience (Anand & Khanna, 2002; Shan, Kogut, & Walker, 1994; Zollo, et al. 2002), we attempt to develop a more comprehensive and fine-grained theory of alliance experience accumulation *across* and *within* alliances as drivers of

joint R&D performance. We draw on operations management, economics, and organization theory to illuminate the benefits that can accrue through accumulated alliance experience over time. We focus on R&D alliances, and relate different types of alliance experience effects to the performance of individual alliances. In particular, we differentiate between the alliance experience gained with a specific partner versus a generalized alliance experience gained across a diverse set of organizations. While others have suggested a positive linear relationship between alliance experience and performance (Anand & Khanna, 2000; Shan et al., 1994; Zollo, et al. 2002), we also consider the possibility that the relationship between alliance experience and subsequent alliance performance may be characterized by diminishing marginal returns.

Besides our attempt to further develop the theory of alliance experience accumulation, we also strive to make a methodological contribution. Since the processes underlying the relationship between alliance experience accumulation and alliance performance are not likely to emerge from a cross-sectional, survey-based study, we link the performance of individual R&D alliances to data that tracks alliance activity among participating organizations in the pharmaceutical industry over a lengthy time period (1980-2000). Moreover, to test our hypotheses, we introduce a performance outcome that is causally proximal to our focus on alliance experience. We examine *joint project-level* new drug development outcomes between established pharmaceutical companies and their partners in the new biotechnology industry. Here, we consider general and partner-specific alliance experience, and argue that both impact the likelihood of a collaborative R&D project resulting in a successfully developed and marketable new drug. When analyzing general alliance experience, we assess how the alliance experience of *each* partner individually impacts joint R&D project performance, while controlling for the other partner's alliance experience. From an empirical standpoint, the performance of R&D alliances remains largely unexplored (Osborn & Hagedoorn, 1997). From a managerial perspective, collaborative new drug development for large pharmaceutical companies has become critical to firm performance as indicated by the fact that the industry's collective R&D expenditures have tripled over the last decade, yet the number of new drugs approved each year has remained flat (*Business Week,* 2002).

THEORY AND HYPOTHESES

General Alliance Experience and Alliance Performance

We attempt to develop the notion of alliance experience by drawing on the traditional experience curve literature (for a review Dutton and Thomas, 1984). Accordingly, we begin by reviewing relevant experience curve literature before linking alliance experience effects more explicitly to the jointly-determined performance of individual alliance projects. Rooted in operations management research, experience effects refer to systematic unit-cost reductions that occur over accumulated production volume (Yelle, 1979). Early studies focused on airframe manufacturing and found that each time accumulated output was doubled, unit costs decreased to about eighty percent of their prior level (Alchian, 1963). Productivity improvements based on experience effects have also been documented in a variety of other industries such as shipping, steel, rayon, and nuclear power (Dutton & Thomas, 1984). These studies reveal that the relationship between production costs and volume production is not linearly negative but instead declines at a decreasing rate.

Theoretically, experience effects are composed of learning and scale effects (Hall & Howell, 1985). Learning effects appear to be a key explanatory variable underlying the experience curve effect as Lieberman (1984) documented in his study of the chemical industry, where prices fell with cumulative output while controlling for time effects. Organizational learning occurs in an iterative fashion when firms engage repeatedly in the focal activity, draw inferences from their experiences, and are able to store and retrieve the inferred learning for future engagements in the focal activity (Levitt & March, 1988). The more complex a process, the more significant the learning potential.

While most empirical studies have documented learning-by-doing effects in the manufacturing sector (Dutton & Thomas, 1984), there is also evidence that learning effects appear to play an important role in service industries based on studies conducted in the health care, fast food, and hotel industry (Baum & Ingram, 1998; Darr, Argote, & Epple, 1995; Luft, Bunker, & Enthoven, 1979). Luft et al. (1979), for example, found that more experienced health care providers of complex procedures like heart surgeries performed significantly better in terms of a lower mortality rate than less experienced providers. Baum and Ingram

(1998), in their study of the Manhattan hotel industry, found evidence that the relationship between organizational experience and survival is U-shaped.

Economies of scale, as the second driver underlying the experience curve effect, are reductions in average unit cost as output increases. Economies of scale are attributable to the ability to spread fixed, indivisible cost over a large production volume. Large scale production runs also allow for a greater division of labor and are thus a source of economies of specialization (Smith, 1937). The ability to spread fixed costs over a large output and the benefits of specialization hold not only for manufacturing activities, but also for other organizational activities. For example, the cost of maintaining an in-house legal counsel in terms of salary can be considered fixed regardless of how many cases the attorney handles. As more attorneys are on staff, each attorney can specialize in a certain field and thus deepen their respective competence and expertise.

In recent theoretical work, scholars have posited that the effective management of a firm's alliances can lead to superior alliance performance and thus contribute to firm's competitive advantage (Dyer & Singh, 1998; Ireland, Hitt, & Vaidyanath, 2002). In the alliance context, experience can play a beneficial role in improving alliance outcomes by allowing firms to develop, refine, and leverage intra- and inter-organizational routines to solve problems or alleviate strategic concerns that arose from past alliances. Moreover, accumulated alliance experience may also aid the firm in assessing and selecting appropriate future alliance partners for their specific knowledge contribution. For example, Anand and Khanna (2000) found support for learning effects in joint ventures as they showed that the stock market responded positively to alliance announcements by firms with prior alliance experience. Barkema, et al. (1997) documented how learning accumulated through repeated engagements in domestic joint ventures promoted the longevity of international joint ventures. Some empirical evidence also indicated that more experienced firms can manage a larger number of alliances simultaneously (Rothaermel & Deeds, 2001).

In parallel to the traditional experience curve literature, experience effects in the alliance context may again be divided into learning and economies of scale effects. Learning effects arguably play a more prominent role since they allow for the initiation of a new, more

steeper experience curve, while economies of scale effects allow merely for moving down an existing experience curve (Yelle, 1979). At its heart, a model of learning through experience places a central role on the learning benefits of repeated engagements in a focal activity.

The locus of this learning process can reside in the development of experience among a cadre of dedicated alliance managers operating at the corporate level. Some firms have recently begun to institutionalize alliance experience to enhance alliance performance. Dyer, Kale, and Singh (2001: 38) describe the role of such dedicated alliance functions as coordinating all alliance-related activity within the firm, and to institutionalize "processes and systems to teach, share and leverage prior alliance-management experience and know-how throughout the company." For example, Eli Lilly established an Office of Alliance Management in late 1999.[1] Lilly views this dedicated alliance function as an "integrator, intermediary and catalyst for best practice performance" (Gueth, Sims, & Harrison, 2001: 4). Prior research found that firms with significant alliance experience tended to create such dedicated alliance functions (Kale, Dyer, & Singh, 2002). Moreover, firms with a dedicated alliance function enjoyed better alliance performance than firms without such a function, as assessed by both managerial perception and stock market response. Alliance experience may be embodied in manuals, databases, diagnostic tools, and simulations that codify the key insights gained. Experience may also result in new routines that facilitate internal coordination. New organizational structures that are charged with developing a firm's alliance capabilities can aid in knowledge codification and facilitate cooperation across different functional areas within the firm.

Economies of scale effects can also contribute to improving alliance performance as they allow for greater specialization and differentiation among alliance managers, which should lead to greater expertise in relevant areas. Moreover, the fixed costs of maintaining a cadre of alliance managers can be spread over more alliances, and thus contribute to a positive impact on alliance performance. These arguments suggest that in the alliance context, firms with more general alliance experience are likely to develop more effective capabilities,

[1] Author's communication with Anton Gueth, Director of the Office of Alliance Management at Eli Lilly.

routines, organizational structures, and achieve a higher level of specialization and expertise for collaborating, which should lead to enhanced alliance performance.

Hypothesis 1a: The general alliance experience of a firm has a positive impact on subsequent alliance performance.

The relationship between alliance experience and alliance performance may not be linearly positive, however, but may exhibit diminishing marginal returns. This implies that each additional alliance experience contributes progressively less to a firm-level alliance capability. Early alliance experiences allow for significant learning, which tapers off in subsequent alliance experiences. Empirical studies on factors underlying the experience curve have shown that learning does indeed taper off, and in fact, fairly rapidly (Hall & Howell, 1985; Lieberman, 1984). Even though some researchers have found a constant, positive relationship between a firm's alliances and its patents (Shan, et al. 1994) or market value created (Anand & Khanna, 2000), others have produced evidence that there exist decreasing returns to a firm's alliance intensity and experience. In studies that assumed one critical measure of alliance performance is the development of new products, for example, researchers found an inverted U-shaped function between a firm's number of concurrent alliances and its rate of new product development (Deeds & Hill, 1996; Rothaermel, 2001). In a similar manner, Sampson (2002) found that the relationship between a firm's alliance experience and firm-level patenting propensity was characterized by decreasing marginal returns.

Firm alliance experience may follow the economic principle of diminishing marginal returns for a number of reasons. Firms tend to enter the most promising alliances first, thereby leading to poorer outcomes in subsequent alliance activity (Deeds & Hill, 1996). Moreover, Sampson (2002) suggested that organizational inertia might be responsible for diminishing returns to alliance experience. Once firms have developed and established routines, policies, and procedures based on a certain set of early alliance experiences, they may become trapped by this competency (Levitt & March, 1988) through a continued focus on similar alliance experiences that allow for little or no additional learning. Choosing alliance partners, for example, that are similar to those of past alliances restricts variation in

alliance experience and thus reduces organizational learning. Even entering alliances with new partners may not allow for significant new learning since there are also limits to what can be learned through experience (Dutton & Thomas, 1984; Simonin, 1997). Finally, entering an alliance with a certain partner may foreclose alliance opportunities with other potential partners due to alliance-based competitive dynamics (Silverman & Baum, 2002).

Given that alliance relationships often last several years, firms generally engage in multiple alliances concurrently in time. Thus, limits to a firm's alliance capacity may also contribute to diminishing returns to alliance experience. Generally, firms face limited financial and, more importantly, limited managerial resources. Simultaneously managing multiple alliances may thus accentuate the cognitive limitations of managers (Simon, 1947). Prior research provided some empirical support for cognitive limits to managerial capabilities when documenting diminishing marginal returns to internationalization on the speed of technological learning and firm performance (Hitt, Hoskisson, & Kim, 1997; Zahra, Ireland, & Hitt, 2000). In the alliance context, cognitive limits of managers may result in inferior partner selection and alliance management and thus lead to a subsequent decline in alliance performance. If finite managerial resources are spread over ever more alliances, the marginal return of subsequent alliances is declining, and may even be negative beyond some point (Deeds & Hill, 1996; Rothaermel, 2001). Consistent with this hypothesis, Hoang (2002) showed that pharmaceutical-biotechnology alliance formation rates slowed past a moderate level of concurrent alliance participation.

Taken together, we posit that the relationship between a firm's prior alliance experience and the performance of subsequent alliances exhibits diminishing marginal returns because firms enter the most promising alliances first, learning benefits may taper off, organizational inertia may set in, there a limits to what can be learnt by experience, certain alliances may foreclose other alliance opportunities, and managers are susceptible to cognitive limitations.

Hypothesis 1b: The impact of a firm's general alliance experience on subsequent alliance performance exhibits diminishing marginal returns such that the relationship is positive, but decreases at high levels of general alliance experience.

Partner-Specific Alliance Experience and Alliance Performance

The arguments above suggest that general alliance experience is derived from a portfolio of alliances across a diverse set of partners. However, a portion of the knowledge and skills that accumulate based on repeated alliance activity over time may also be partner-specific. As such, alliance experience may be as much a dyadic construct as it is a firm-level one. Subsequently, some scholars have argued that the ability of firms to learn from one another in an alliance depends not so much on the capabilities of the individual firms involved in the alliance but rather on the capabilities of the pair at the dyad level. For example, Lane and Lubatkin (1998), in their study of inter-organizational learning in R&D alliances, found that the ability of two firms in a dyad to learn from one another was determined by the similarity between the firm's knowledge bases, organizational structures, and dominant logics. Such partner-specific similarities facilitated even the transfer of tacit knowledge. More recently, Zollo et al. emphasized the emergence of interorganizational routines, defined as "stable patterns of interaction among two firms developed and refined in the course of repeated collaborations" (2002: 701), when explaining perceptual assessments of alliance performance.

A social embeddedness view also supports the notion of partner-specific alliance experience. In a seminal article, Granovetter (1985) questioned the atomistic view underlying much theorizing in organizational economics, and argued that firms are embedded in social networks that influence their behavior. Recent research on alliance formation patterns over time has echoed such a social embeddedness perspective as it suggested that firms are more likely to engage in subsequent alliances with the same prior partners. In a study of investment bank relationships, Podolny (1994), for example, has shown that firms tend to restrict their syndication activities to other investment banks with which they have transacted with in the past. One explanation for this tendency is that partner-specific knowledge can be leveraged to facilitate subsequent collaborations. From an organizational perspective, the refinement of partner interfaces and the development of partner-specific decision-making routines should enhance subsequent alliance performance (Inkpen & Dinur, 1998; Zollo, et al. 2002).

Repeated alliances between firms might evolve into a more stable interfirm relationship, often accompanied by greater trust (Gulati, 1995a). When interviewing Anton Gueth, Director of the Office of Alliance Management at Eli Lilly, he indicated that multiple ties to the same partner create an ecosystem of cooperation that tends to be more stable and successful than stand-alone binary alliances. Partner-specific alliance experience often becomes institutionalized over time as firms develop stable role definitions for boundary spanners and codify informal commitments (Zaheer, McEvily, & Perrone, 1998). Experience with a specific partner also allows for improved interactions based on trust and accumulated social capital that can lead to greater alliance effectiveness (Tsai & Ghoshal, 1998; Zaheer, et al., 1998). Gulati (1995a) has produced evidence that repeated partnering created trust within the dyad. Thus, we argue that partner-specific alliance experience resides at the dyad level and may lead to the development of partner-specific knowledge, routines, organizational structures, and trust, which in turn should enhance subsequent alliance performance.

Hypothesis 2a: Partner-specific alliance experience has a positive impact on subsequent alliance performance.

Not unlike the diminishing returns argument relating to the entire portfolio of alliances, we also posit that the relationship between partner-specific alliance experience and alliance performance may exhibit diminishing returns over subsequent alliances. Not only are the alliance opportunities between two firms limited, but additional alliances with the same partner beyond the first few may also provide diminishing returns to the partners in terms of learning, scale, or complementarities to be exploited. Further, additional alliances with the same partner may only provide limited, if not redundant information (Gulati, 1995b). Repeated allying with the same partner can lead to inertia in the firm's alliance capability and thus reduce learning benefits (Sampson, 2002). Conceivably, inertia may also set in at the dyad-level, and thus dyads that engage in repeated partnering over time may be slow in incorporating the most recent knowledge to enhance alliance performance.

Firms might also be motivated more by social and status considerations when entering alliances (Podolny, 1994), rather than by performance considerations alone. This mechanism could lead to curtailed alliance performance when the same two firms in a dyad continue to

enter alliances with one another. When relating prior alliances between pairs of firms to future alliance formation, Gulati (1995b) found empirical support for an inverted U-shaped relationship. In a similar manner, Chung, Singh, and Lee (2000) provided empirical evidence for such a relationship when studying investment banks syndicating stock offerings. Thus, we argue that the positive impact of partner-specific alliance experience on alliance performance may taper off with subsequent alliances with the same partner because of limited alliance opportunities, limited benefits in terms of learning, scale, and complementarities, inertia in partner-specific routines at the firm- and dyad-level, and social as well as status considerations.

Hypothesis 2b: The impact of partner-specific alliance experience on subsequent alliance performance exhibits diminishing marginal returns such that the relationship is positive, but decreases at high levels of partner-specific alliance experience.

METHODS

Owing to a number of formidable empirical challenges to understanding the determinants of alliance performance, Gulati concluded in his comprehensive review of the alliance literature that "the performance of alliances remains one of the most interesting and also one of the most vexing questions" (1998: 309). For example, objective performance measures at the dyad- or alliance-level are hard to obtain (Anderson, 1990). The difficulty of obtaining such data is only compounded when trying to gather data across a large number of alliances to ensure representativeness. Hence, case studies (Doz, 1996; Dyer, 1997) and surveys where performance information is generally obtained from only one partner in the alliance (Parkhe, 1993; Zollo, et al. 2002) remain the principal methods for studying alliance performance.

These studies have certainly advanced our understanding of alliance performance, however, they also contain some inherent weaknesses as a consequence of their research design. While case studies are rich sources of information, they are often vulnerable to criticisms of generalizability. Similarly, data collected from a single informant regarding key characteristics of the performance of an alliance and, in the same instrument, information

about theoretically relevant characteristics of the relationship are subject to criticisms. These studies are prone to common method bias where relationships across variables could be inflated. In addition, respondents are likely to engage in retrospective sense-making, observing the performance of an alliance and highlighting characteristics of the relationship or events that reinforce the observed outcome. Another weakness of the perceptual approach to measure alliance performance is that it has relied mainly on the subjective assessment of only one partner in an alliance, despite the fact that alliance outcomes are jointly determined.

We step into this fray with a study that was designed with the above methodological challenges in mind. Namely, our data are dyadic, yield proxies for different kinds of alliance experience, and in turn relate their impact to an objective outcome measure obtained across a large number of alliances over time. In particular, we relate the impact of general alliance experience of each partner, on the one hand, and partner-specific alliance experience within a pair of firms, on the other hand, to the performance of *joint project-level* new drug development collaborations. We consider these projects successful if they completed the regulatory drug approval process imposed by the Federal Drug Administration (FDA), and subsequently received endorsement for sale as a new drug therapy.

Research Setting

The dyads in our study consist of alliances between pharmaceutical companies and their biotechnology partners. Traditional pharmaceutical companies like Novartis or Pfizer were established under the technological paradigm of chemical screening and are attempting to adapt to the emergence of biotechnology, which is mainly based on recombinant DNA technology. The new biotechnology is considered to be a competence-destroying process innovation for established pharmaceutical companies in the way new drugs are discovered and developed (Stuart, Hoang, & Hybels, 1999). Alliances with new biotechnology firms are one way for pharmaceutical companies to adapt to the new biotechnology (Rothaermel, 2001).

We focus on bilateral dyadic R&D alliances based on formal interfirm agreements rather than on informal collaborations (like handshake deals). While focusing on formal

alliances captures only the tip of the iceberg of interfirm cooperation in the pharmaceutical industry, a focus on these collaborations allows us to analyze alliances that have been elevated to the level of ongoing relationships between organizations. Moreover, a focus on bilateral dyadic relationships is appropriate since this industry generally does not exhibit group structures or alliance blocks like the automobile or airline industries (Koput and Powell, 2002).

These bilateral alliances are a prominent method for sourcing the new technology since biotechnology companies play a leading role in the creation of new knowledge within this industry (Powell, Koput, & Smith-Doerr, 1996). For example, prior research demonstrated that alliances between established pharmaceutical companies and biotechnology firms are characterized by learning (Lane & Lubatkin, 1998). In this perspective, alliances are viewed as a means whereby firms can access new knowledge that lies outside their boundaries and, through recombination with existing internal knowledge, leverage it to exploit new market opportunities (Grant & Baden-Fuller, 1995). In addition to the learning benefits, these alliances are also intended to have a direct impact on boosting pharmaceutical companies' new drug pipelines (Rothaermel, 2001).

Sample and Data

In a first step toward creating a dyadic database, we identified all pharmaceutical companies active globally in biotechnology as of 1980 through studying SIC listings and a variety of industry publications such as *BioScan, Burrill & Company Life Sciences Annual Industry Reports, Ernst & Young's Annual Biotech Industry Reports, IMS Health Global Pharma Industry Reports, Scrip's Yearbooks on the Global Pharmaceutical Industry,* among others. The year 1980 marks the beginning of extensive interfirm cooperation in biotechnology owing to three important events (Stuart, et al. 1999: 323): 1) the decision by the Supreme Court that new life forms can be patented; 2) the passage of the Patent and Trademark Act, which allows universities to patent discoveries funded with federal dollars; and 3) the successful initial public offering of Genentech, the first public biotechnology firm. At the start of our study period in 1980, our sample was composed of 43 pharmaceutical firms

globally. This number is consistent with the oligopolistic industry structure of the pharmaceutical industry where a few large companies, active in proprietary drug discovery and development, dominate the industry.

In fact, the industry becomes more concentrated over the time period of our study. At the end of our study period in 2000, the four largest firms accounted for about one third of all the sales in the pharmaceutical industry. As a consequence of consolidation, the number of distinctive pharmaceutical firms in our sample fell accordingly from 43 to 30 as of 2000. Due to this consolidation trend over this twenty-one year time period, we accounted for an acquisition or merger by combining the alliances and patent data of the relevant firms. This procedure indicated the need to create a comprehensive "family tree," linking all companies in existence as of 2000 back to their various "ancestors" as of 1980, the beginning our study period. For example, two firms in the starting sample, Upjohn and Pharmacia merged in 1995. In our analyses, the resulting organization was given the combined alliance and patent data of both companies and updating of data proceeded using the organization's new identity. To assess whether this procedure affected our results, we created an indicator variable with 1 = firm merged with or acquired another firm. This variable was not significant in explaining collaborative R&D performance.

Once the sample of pharmaceutical firms was determined, we found, in a second step, all collaborative biotechnology projects that these pharmaceutical firms had initiated during the 1980-1998 time period. These data were obtained from *Lifecycle*©, a proprietary database maintained by IMS Health, a pharmaceutical industry research firm. *Lifecycle*© is commercially available and provides fine-grained data on R&D projects covering a large number of pharmaceutical firms globally. To obtain these data, IMS Health associates collect information from governmental agencies, attend industry conferences, scan issued patents and scientific publications, and maintain contacts with scientists and managers within the focal firms. These data are maintained in qualitative form. Since the project descriptions in *Lifecycle*© are highly technical in terms of medical language, these data were coded by a researcher holding a Doctor of Medicine degree to ensure that collaborative projects were building on the new biotechnology. This process yielded 292 collaborative biotechnology

projects in which 30 distinct pharmaceutical companies cooperated with 145 different, independent biotechnology partners during our study period, 1980-2000.

To gather information on overall alliance experience for both, the pharmaceutical and the biotechnology partner over time, we linked the *Lifecycle*© data to alliance information obtained from various volumes of *BioScan*, an industry publication, and *Recombinant Capital*, a consulting firm specializing in the life sciences. *BioScan* and *Recombinant Capital* appear to be the two most comprehensive publicly available data sources documenting alliance activity in the global biotechnology industry. Both sources are fairly consistent and accurate in reporting alliances (their inter-source reliability was greater than 0.90). We collected data on alliance activity over time beginning in 1980 until 1997, one year prior to the last year of possible joint R&D project initiation.

Finally, we obtained patent data assigned by the U.S. Patent and Trademark Office (USPTO) from 1975 onwards. Applying a five year moving window to assess the impact of firm patenting on innovative performance is consistent with prior research (Ahuja, 2000; Stuart & Podolny, 1996). We focused on patents obtained in the U.S. since it represents the largest market for biotechnology worldwide, and thus firms generally patent first in the U.S. (Albert, Avery, Narin, & McAllister, 1991). In addition, firms active in biotechnology have a strong incentive to patent since intellectual property protection has been held up consistently in court and is thus considered to be quite strong (Levin, Klevorick, Nelson, & Winter, 1987).

Variables and Measures

We attempted to proxy our dependent variable, *Project Success*, by an objective performance measure. We chose a binary variable, with 1 indicating a successful completion of a new drug development project resulting in an FDA approved, marketable new drug. While the study covered a lengthy time period to ensure sufficient numbers of successes and failures, not all projects were completed by the end of our study period due to the protracted nature of the new product development process in the pharmaceutical industry. Those projects that were still in a pre-clinical stage, phase I, II, or III clinical trials as of 2000 were not included in the final analysis. Hence, out of the initial 292 joint projects considered, 63

projects were successfully completed and 95 were discontinued (failure) by 2000, for a final sample of 158 projects (54 percent) for which an objective and unequivocal outcome measure was available.[2] Based on the binary nature of our dependent variable, we applied a logistic regression model estimating how general and partner-specific alliance experience impact the probability of a successful joint R&D project.

We proxied general alliance experience by the number of R&D alliances entered into by each firm in the dyad up to the year prior to the start of the focal biotechnology collaboration. We proxied general alliance experience for *both*, the pharma and the biotech partner (*Pharma Alliance Exp*, *Biotech Alliance Exp*). This allows us to test the impact of general alliance experience of each of the two firms in the focal project, while controlling for the respective partner's alliance experience. We proxied partner-specific alliance experience by the number of prior R&D alliances between the pair of firms in the focal dyad (*Dyad R&D Exp*). Care was also taken to exclude those alliances that would be counted as partner-specific alliance experience from the general alliance experience measure, to ensure the independence of the two experience measures proxing for benefits gained *across* diverse partners and *within* partnerships. As suggested by Aiken and West (1991), the resulting variables were centered to reduce the problem of collinearity. We squared the centered variables to test the argument that the impact of alliance experience exhibits diminishing returns to alliance performance (*Pharma Alliance Exp Squared, Biotech Alliance Exp Squared*).

To control for other firm and project-level confounding factors that may explain joint project-level performance, we included a number of variables based on past research (Henderson and Cockburn, 1994) and our knowledge of the industry. We controlled for the year in which the project was initiated (*Project Year*). Given a system of clinical trials divided into different phases, successful projects take longer to emerge. Hence, projects that were initiated later in the study period have had sufficient time to pass to allow for failures –

[2] A comparison of the means between the final sample and the projects that were still ongoing showed little evidence of systematic differences. Using the independent variables from our model in post-hoc tests, the two groups only differed to the extent that projects that were still ongoing were less likely to be between firms who had prior alliances and were slightly more likely to be protected by a patent.

but not successes – to be observed. Because of this right-censoring, we would expect a negative effect of *Project Year* on alliance success since more recently initiated projects are less likely to be successfully completed.

We also tested if the likelihood of success is affected by the number of indications or disease states that a drug can target (*Indications*). If the new drug has been assigned several indications, it is affecting the biological process or the molecule that is common among those indications. For example, rheumatoid arthritis, Crohn's disease, and HIV infection are listed as indications for a successful project in our sample resulting in the drug Infliximab, which was discovered by the biotechnology firm MedImmune and developed by the pharmaceutical company Johnson & Johnson, which now markets this new biotechnology drug under its commercial name Remicade. The therapeutic action of this drug is to affect TNFa, which plays a role in the origination and development of these diverse diseases. Multiple indications that share underlying mechanisms or a target molecule, can draw on a greater number of research models for testing and allow for greater knowledge transfer across the indications, thereby increasing the chances for a successful new product.

We also noted whether projects were protected under a U.S. and/or European patent (1 = *Patent Protection*). The assumption is that a patent protected project is viewed as potentially more valuable and thus attracts more resources and managerial attention, which in turn should impact its probability of success. Moreover, to assess differences in firm R&D quality, we included the number of past successes of each partner in prior joint biotechnology drug development projects (*Pharma Past Success, Biotech Past Success*). This control variable is important since it allows us to assess the probability of current joint project success, while controlling for past successes.

A final measure of technological competency in the new biotechnology area was captured through patent data. We obtained patent counts for both firms in each partnership and updated them yearly. Because pharmaceutical firms patent in more diverse areas than biotechnology firms, we tried to eliminate unnecessary noise in our measure by focusing on technological areas where biotechnology patents were emerging, such as U.S. patent class 435: "Chemistry: Molecular Biology and Microbiology." Building on the work of

Trajtenberg (1990), each patent was weighted by the number of subsequent patent citations received to capture underlying patent portfolio quality. As a result, a cumulative variable, *Wgtd Patents Pharma* and *Wgtd Patents Biotech*, was calculated for each firm in the dyad by adding annual weighted patent counts up to the year t-1 of the focal joint project.

RESULTS

The average pharmaceutical company in our sample had entered twenty-four alliances, while the average biotechnology partner had formed seven alliances. About 60 percent of all pharma-biotech pairs had at least one R&D collaboration prior to the current one under investigation. The average project targeted more than one disease category. A little more than 40 percent of the projects were protected under patents. The average pharmaceutical company had about 1.6 successful past projects, whereas every third biotechnology partner had one past successful project. The large pharmas produce on the average five times more patents than their small biotech counterparts. Table 1 depicts the descriptive statistics and bi-variate correlation matrix, while Table 2 shows the regression results. Model 1 contains the control variables only, serving as our baseline model. Model 2 evaluates the linear impact of general and partner-specific alliance experience (H1a and H2a), while model 3 tests for diminishing returns (H1b and H2b).

Insert Tables 1 and 2 about here

Hypothesis 1a predicted that a firm's general alliance experience has a positive impact on alliance performance, while hypothesis 1b suggested that this relationship is characterized by diminishing marginal returns. These two competing hypotheses were evaluated for both, the general alliance experience of the pharmaceutical firm and the general alliance experience of its biotechnology partner. Multi-collinearity is an endemic problem in regression models that simultaneously contain a linear and a squared term of the same variable. To assess this potential threat, we estimated the variance inflation factors and found that no variable had a variance-inflation factor greater than 7, below the recommended ceiling of 10 (Kleinbaum, Kupper, & Muller, 1988).

The results obtained suggest that general alliance experience matters. However, as indicated in model 3, which represents a significant improvement over the baseline model ($\chi^2 = 12$, $p < 0.07$), it is the general alliance experience of the pharmaceutical firm's *biotechnology partner* that significantly impacts joint project success, while the general alliance experience of the pharmaceutical company itself is insignificant. Therefore, hypothesis 1b is supported since the general alliance experience of the biotechnology exhibits diminishing marginal returns (model 3). These results were robust to a random-effects specification that controls for correlations that may exist when identical dyads appear multiple times in the database.

We found no support for hypothesis 2 that posited that particular benefits could be achieved through past alliance participation with the focal partner. Partner-specific experience does not seem to impact alliance performance when considering the pharma-biotech collaborative projects in our sample.

Our findings also show that a number of project-level control variables were significant predictors of joint project success. As expected, the later the project was initiated in our study period the lower its probability of a successful completion due to the protracted nature of the new drug development process. Moreover, the greater the number of indications the project targeted, the higher its probability of success. Finally, projects that resulted from patent-protected intellectual property were also more likely to succeed. Taken together, firms seem to devote their most competent managers and necessary resources to these alliances as they are crucial to the firms' competitive advantage. The finding that potentially broader applicable and proprietary drugs are more likely to succeed in joint development projects appears to be a reflection of the winner-take-all competition in the market for pharmaceuticals.

DISCUSSION

Drawing on a diverse set of literatures, we attempted to contribute to a theoretical understanding of alliance experience effects and their impact on alliance performance. We highlighted learning and scale effects *within* and *across* alliances to test whether firms benefited from their partner-specific and general alliance experience. Specifically, we examined whether biotechnology drug development projects between pharmaceutical and their biotechnology counterparts were affected by each of the partners' alliance experience as well as their joint dyadic alliance experience. While allying has been argued to impact aggregated firm-level variables (Deeds & Hill, 1996; Rothaermel, 2001; Sampson, 2002) or stock market responses (Anand & Khanna, 2000), we found that alliance experience directly impacts the performance of *individual* alliances. In particular, we demonstrated that prior general alliance experience has a positive impact on the likelihood of alliance success. This effect decreases as alliance experience increases, suggesting that there are diminishing returns to general alliance experience. Our results resonate with empirical research documenting that interfirm differences in the ability to create value through alliances persist over time, and are a potential source of firm competitive advantage (Anand & Khanna, 2000; Kale, et al. 2002).

Interestingly, while assessing the general alliance experience of both partners in an alliance, we found that only the general alliance experience of the biotechnology partner mattered in explaining joint project success, while controlling for the general alliance experience of the pharmaceutical firm. This result suggests that the benefits of alliance experience depend on the extent to which organizations can actively mobilize and leverage their experience. Simonin (1997) demonstrated that alliance experience alone is not sufficient to gain collaborative benefits. He argued that experience must be internalized and explicit collaborative know-how developed to positively impact collaborative performance. This might be a more difficult task for large pharmaceutical companies than for the smaller biotechnology partners. The difference between the two populations of organizations is striking both in terms of their relative size and their degree of vertical integration. For

example, the European pharmaceutical company Novartis, the number eight worldwide, had revenues of $20 billion in 1999, which was just short of the combined revenues of all biotechnology firms ($22 billion) (Giovannetti & Morrison, 2000). Moreover, while the large pharmaceutical firms are fully vertically integrated, most biotechnology firms focus on the upstream R&D activities of the value chain (Pisano, 1991).

Different levels of organizational complexity, as a reflection of the differences in size as well as degree of vertical integration and diversification between pharmaceutical and biotechnology companies, might explain why large firms appear to be unable to leverage their alliance experience. A corporate-level competency may develop within the large firm for identifying and negotiating alliance partners, but the benefits to alliance experience may hinge on the extent of coordination across disparate functional groups and hierarchical levels where alliance experience resides. Most pharmaceutical firms have just recently begun to create organizational structures, processes, and routines to leverage and support their alliance activities. For example, Eli Lilly's Office of Alliance Management was not fully functioning until 2000 when its staffing was complete.[3] Many other pharmaceutical companies lag Lilly's organizational innovation since Lilly is considered a leader in alliance management in the pharmaceutical industry (*PriceWaterhouseCoopers*, 2000).

To ensure coordination across disparate functional groups and hierarchical levels, for example, Lilly's alliance management process prescribes that each alliance is managed by a three person team: alliance champion, alliance leader, and alliance manager (Gueth, et al. 2001). The alliance champion is a senior executive responsible for high-level support and oversight. The alliance leader has the technical expertise and knowledge needed for the specific area and is responsible for the day-to-day management of the alliance. The alliance manager, positioned within the Office of Alliance Management, serves as an alliance process resource and business integrator between the two alliance partners, and provides alliance training and development, as well as diagnostic tools, etc. Such an alliance management process may be an example of how to leverage alliance experience within a large, multi-divisional company and thus contribute to a firm-level alliance capability.

[3] Author's communication with Anton Gueth, Director of the Office of Alliance Management at Eli Lilly.

On the other hand, there are fewer such structural barriers to leveraging of alliance experience in smaller firms. The newer biotechnology firms are likely not as hamstrung by organizational inertia as the large established pharmaceutical companies are. Moreover, smaller firms have a greater incentive to learn from their experience because these relationships are more critical to their survival. For most biotechnology firms, alliances are the most significant sources of revenues and capital as well as frequently the only access to the market for pharmaceuticals (Pisano, 1991). A large firm's strategic intent to leverage alliance experience may be lower because it represents a smaller share of its total investment in a particular activity.

Our finding that general alliance experience exhibits diminishing returns contrasts with work on another corporate-level strategy, mergers and acquisitions (M&As), where a U-shaped function was reported between acquisition experience and acquisition performance (Haleblian & Finkelstein, 1999). The initial decline in the relationship between prior acquisition experience and subsequent acquisition performance was explained by the notion that firms inappropriately generalize from their initial acquisition experience. The literature on cognitive psychology termed this problem "negative transfer," as it refers to the possibility of applying knowledge obtained in one activity to another activity, which appears to be superficially similar, yet is fundamentally different. Knowledge obtained in disparate situations does not allow for generalization based on prior experience (Cohen & Bacdayan, 1994; Gick & Holyoak, 1987). Benefits to experience would only come after a sufficient level of exposure to related and unrelated acquisitions that would allow firms to better judge when – and when not – to apply prior experience.

On the average, alliances are much more frequent firm activities compared to M&As, which might explain why the relationship between general alliance experience and alliance performance is characterized by an inverted rather than a U-shaped function. Moreover, we focus on a within-industry study and a specific class of alliances (research alliances intended to generate new drugs). The alliances appear to be more homogenous, and thus the kind of variation in alliance experience that might lead to a U-shaped relationship between experience and performance is curtailed. Diminishing returns to general alliance experience may not

hold when firms engage in a richer variety of alliances, i.e., alliances that link firms to different knowledge bases and product markets. Alliances entered to adapt to different market uncertainties (Park, Chen, & Gallagher, 2002) or accessing different competencies across diverse countries (Hitt, Dacin, Levitas, Arregle, & Borza, 2000) may provide greater partner variety.

Based on our findings, it appears that partner-specific alliance experience accumulated between pharmaceutical and their biotechnology partners did not impact subsequent alliance performance. Our work contrasts with survey-based evidence that found partner-specific alliance experience does affect alliance performance (Zollo et al., 2002). An important difference between the Zollo et al. (2002) study and our own lies in the respective dependent variable. Zollo et al.'s (2002) dependent variable is based on a composite score of three different perceptual assessments of alliance performance by one alliance partner, highlighting satisfaction in knowledge accumulation, options value, and overall satisfaction. Our dependent variable reflects the objective outcome (success or failure) of a joint new drug development project. The apparent contradictory findings may be reconciled by viewing partner-specific alliance experience as contributing to broader organizational objectives that may go beyond the performance results of the immediate alliance. For example, an alliance project that would be classified as a "failure" in our sample, might still be a success based on Zollo et al.'s (2002) measure, if the firm derived learning and/or option value from this project.

Moreover, the mechanisms underpinning the consistent finding that firms prefer partners with whom they have dealt with in the past (Chung, et al. 2000; Gulati, 1995b; Hoang, 2002), may be more driven by factors related to social embeddedness and status concerns rather than performance criteria. For instance, firms may narrow the set of potential partners by focusing on those with whom they have built trust through repeated prior alliances (Gulati, 1995a; Zaheer, et al. 1997) or those who are similar or higher in status (Chung, et al. 2000; Podolny, 1994) rather than basing the decision to ally solely on performance criteria.

Our second avenue of intended contribution is methodological in nature. We concur with prior research emphasizing that alliance outcomes are most appropriately studied at the

level of the *individual* alliance (Parkhe, 1993; Zollo, et al. 2002). In contrast to prior work, however, we focused on an objective, jointly determined, and unequivocal outcome measure of collaborative R&D rather than relying on perceptual performance measures of one partner involved in the alliance. As such, we examined *joint project-level* drug development alliances between pharmaceutical and biotechnology companies over a lengthy time period (1980-2000).

We focused exclusively on R&D alliances, a more proximal driver of R&D performance, to reduce unobserved heterogeneity. R&D alliances represent a more homogenous set of alliances and thus are more likely to lead to learning and experience effects, while mitigating the problem of negative transfer effects. A focus on the same class of alliances may explain why we find significant effects for general alliance experience. Finally, we employed longitudinal, objective secondary data for our independent variables rather than on cross-sectional survey data. We verified the accuracy of our key independent variables proxing for different types of alliance experience by drawing on two comprehensive, but independent data sources to ensure accuracy and completeness.

Limitations and Future Research

Our study is prone to several limitations, which in turn offer opportunities for future research. While alliances may differ in their contribution to experience, we proxied alliance experience by counts of R&D alliances, which is a course-grained measure when attempting to capture alliance experience benefits. Ideally, our alliance experience variables should reflect the *quality* of the collaboration, rather than its *quantity*. Similar arguments have been advanced when studying acquisitions (Hayward, 2002; Vermeulen & Barkema, 2001). Future research should attempt to go beyond simple count measures and develop alliance experience measures that reflect learning benefits over time more accurately. This appears to be particularly pertinent since we found that the relationship between general alliance experience and alliance performance exhibits diminishing marginal returns. Future research should also assess whether diminishing marginal returns to general alliance experience hold when relating

alliance experience to alliance performance across a variety of different value chain activities, diverse industries, and partners from different countries.

While it is an objective assessment of an alliance's performance, relying on a binary outcome measure like successful project completion, narrows our performance measure to some degree. There may be spill-over benefits, like knowledge acquisition, to alliance experience that is not captured by our dependent variable. A future study, linking alliance experience to successful knowledge acquisition more explicitly, may capture the learning benefits from allying more accurately.

An alternative explanation for the impact of alliance experience on alliance performance is that alliance experience proxies for a firm's overall research and development quality. We were heartened, however, by the non-significance of our controls for prior development successes in joint biotechnology drug development and firm patenting. Taken together, we submit that these are reasonable proxies for the R&D competence of a firm, and thus believe that our findings point towards the impact of alliance experience on alliance performance.

We focus on one type of alliance, R&D alliances, in one type of industry, the intersection between pharmaceuticals and biotechnology. Such a focus raises the issue of generalizability. The external validity of our findings would be strengthened if future work would indicate positive benefits to alliance experience in different industry settings. We would also like to emphasize that the performance distribution of successfully commercialized biotechnology drugs is heavily skewed. One successful blockbuster drug like Procrit or Intron A may accrue several billion dollars of revenues for decades, while many approved drugs do not cover their cost of capital (Giovannetti & Morrison, 2000). Thus, while newly commercialized drugs are a proximate measure of alliance performance, future research is warranted to establish a link between successful new drug commercialization and firm financial performance.

Future research should also shed light on the processes of *how* alliance experience is leveraged in the course of the collaboration. While we were able to draw on some anecdotal evidence from one large pharmaceutical company, further, more systematic work is needed on

the possible levers and impediments to leveraging experience within and across alliances. Our discussion thus far has highlighted organizational and strategic factors that may influence this dynamic but there may be other important variables that need to be considered. For example, management information systems that aid in storing and retrieving knowledge gained may play a key role in facilitating the widespread dissemination and use of this knowledge. Some recent evidence suggests that a dedicated alliance function may help in inferring, storing, and retrieving experience from prior alliances (Kale, et al. 2002). These practices may not be as critical for small firms where their size reduces the problem of leveraging organizational experience to that of leveraging individual experience accumulation. In these cases, personnel practices may be more critical than codification efforts since personnel turnover can lead to a depreciation and even dissipation of knowledge gained through allying (Sampson, 2002).

Managerial Implications

While the results raise a number of questions related to the leveraging of alliance experience, they do suggest some points for intervention for alliance managers concerned with raising alliance performance. Firms should assess whether they are providing sufficient resources and organizational support to leverage alliance experience. The non-significance of pharmaceutical alliance experience in predicting new product development success suggests that larger firms face higher hurdles to systematically learning from their alliances. They may face greater obstacles in leveraging their experience due to greater organizational complexity which hinder the storage and retrieval of alliance experience. Increasing efforts to codify knowledge and creating systems to coordinate and disseminate information between alliance managers across projects and across time may be possible mechanisms for the development of an organizational memory that can be leveraged in subsequent alliances.

Finally, firms seeking to optimize alliance performance should carefully assess alternative partners rather than solely turning to partners with whom they have had prior alliance experience. The finding that alliance experience exhibits diminishing marginal returns suggests that alliance managers should assess their own collaborative capacity as well

as that of their potential partner. When working with a familiar partner, it is important to understand how the context for alliance success is altered in the subsequent relationships. For example, incentives to make the alliance a success on both sides may decline as overconfidence may lead managers to be less vigilant and adaptive in subsequent alliances. It may be advisable to sample from a broad set of experiences with diverse partners (Anand & Khanna, 2000), while taking alliance-based competitive dynamics into account (Silverman & Baum, 2002).

CONCLUSION

New product development is a critical driver of sales growth in the pharmaceutical industry. Indeed, in addition to consolidation, alliances are a key strategy being undertaken by pharmaceutical firms eager to fill empty drug development pipelines. We attempted to unravel the impact of general and partner-specific alliance experience on subsequent alliance success. In studying joint development projects between pharmaceutical and biotechnology partners, we found that alliance experience matters. The relationship between alliance experience and alliance performance appears to be characterized by diminishing marginal returns. In addition, only the alliance experience of the biotechnology partner mattered.

Our results are based on a causally proximal and objective outcome variable, joint project development success, and seems to provide some evidence for the existence of an *alliance capability* at the firm level. Apparently, many firms, in particular large, established firms seem to fall short of harnessing their alliance experience. Alliance management (Dyer, et al. 2001; Ireland, et al. 2002), however, should be seen as a distinctive competence, which can find its expression in superior alliance performance and thus can contribute to a firm's competitive advantage.

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TABLE 1

Descriptive Statistic and Bivariate Correlation Matrix

	Mean	Std. Dev.	Min	Max	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Project Success	0.39	0.49	0	1									
2. Project Year	1991	3.53	1980	1998	-0.45**								
2. Indications	1.56	0.95	1	5	0.28**	-0.10							
3. Patent Protection	0.42	0.50	0	1	0.73**	-0.32**	0.14*						
4. Past Success Pharma	1.95	2.70	0	13	0.12	0.13*	0.14*	0.14					
5. Past Success Biotech	0.49	1.11	0	5	-0.01	0.13*	0.05	-.03	0.25**				
6. Wtd. Patents Pharma	1689	1828	0	7602	0.14*	-0.09	0.01	0.14*	0.41**	-0.05			
7. Wtd. Patents Biotech	335	1082	0	6242	0.15*	-0.17**	0.01	0.13	0.08	0.01	0.20**		
8. Pharma Alliance Exp	0	18.93	-21.61	78.39	0.19**	0.01	-0.02	0.18**	0.21**	0.02	0.53**	0.29**	
9. Biotech Alliance Exp	0	11.02	-6.31	51.69	0.16**	-0.17**	-0.06	0.07	0.05	0.04	0.19**	0.56**	0.26**
10. Dyad R&D Alliance Exp	0.0	1.33	-.59	9.41	-0.12	0.09	-0.08	-.16**	0.15*	0.46	0.07	0.07	0.05

N = 158. $^{*}p < 0.10$; $^{**}p < 0.05$

TABLE 2

Logistic Regression Predicting Joint R&D Project Success

	Model 1	Model 2	Model 3
Intercept	688.44***	-712.78***	-843.88***
	(201.68)	(210.09)	(238.141)
Project Year	-0.3478***	-0.3599***	-0.4257***
	(0.1014)	(0.1056)	(.1196)
Indications	0.7324**	0.8209**	0.9776**
	(0.266)	(0.2773)	(0.3117)
Patent Protection	4.0027***	4.1200***	4.5211***
	(0.6205)	(0.6788)	(0.7836)
Past Success Pharma	0.0484	0.0467	0.0418
	(0.1124)	(0.1152)	(0.1317)
Past Success Biotech	0.0533	0.0331	-0.0880
	(0.2853)	(0.3155)	(0.3454)
Wtd. Patents Pharma	-3.2E-5	-1.19E-4	-8.87E-5
	(1.81E-4)	(2.02E-4)	(2.11E-4)
Wtd. Patents Biotech	6.02E-4	-2.71E-4	-4.96E-4
	(2.46E-4)	(3.12E-4)	(3.49E-4)
Pharma Alliance Exp		0.0313†	-0.0224
		(0.0203)	(0.0244)
Pharma All Exp Squared			0.0008
			(0.0007)
Biotech Alliance Exp		0.0462†	0.1710*
		(0.039)	(0.0793)
Biotech All Exp Squared			-0.0042*
			(0.0025)
Dyad R&D Experience		-0.0429	0.4533
		(0.3198)	(0.6237)
Dyad R&D Exp Squared			-0.3156
			(0.2942)
Degrees of Freedom	7	10	13
χ^2	118.64***	123.51***	130.42***
Log Likelihood	-46.51	-44.07	-40.62
Pseudo R^2	0.56	0.58	0.61

† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; Standard Errors in Parentheses