ESSAYS ON NEW PRODUCT DEVELOPMENT ALLIANCES

A Dissertation

by

KARTIK KALAIGNANAM

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2007

Major Subject: Marketing

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ABSTRACT

Essays on New Product Development Alliances.

(August 2007)

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Interorganizational alliances are widely recognized as critical to product innovation. A notable trend is the rapid growth of new product development (NPD) alliances between large, well-established firms and small, growing firms. This dissertation is comprised of two studies on the formation and termination of asymmetric new product development alliances. In study one I examine the factors that drive the changes in shareholder values of the partner firms. I develop and empirically test a model of short-term changes in shareholder values of larger and smaller firms involved in NPD alliances, using the event study methodology on data covering 167 asymmetric alliances in the information technology and communication industries. The model accounts for selection correction, potential cross-correlation across the residuals from the models of firm value changes for the larger and smaller firms, and unobserved heterogeneity. The results suggest that both the partners experience significant short-term financial gains, but there are considerable asymmetries between the larger and smaller firms with regard to the effects of alliance, partner and firm characteristics on the gains of the partner firms. The findings of this study have important implications for managers of both large and small firms.

In study two I develop and test a framework of the determinants of new product alliance (NPA) terminations. The hypotheses for study two are tested on a unique database comprised of 401 new product alliances involving 24 pharmaceutical firms during 1990-2005. NPA terminations are modeled using Cox's proportional hazard specification that accounts for the unobserved heterogeneity of firms with multiple NPAs, competing risks and ties among NPA duration times. The results suggest that NPA terminations are not made in isolation but are influenced by composition of the firm's portfolio. The results also suggest that NPA terminations are predicted to a great extent by competition between alliances (i.e., product market rivalry) and competition within alliances (i.e., partner value). The findings of this study have important implications for managing a portfolio of new product partnerships.

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This dissertation could not have been completed without the support and encouragement of my parents. I owe my parents a lot for providing me the best education possible and for instilling in me the spirit of independent thinking and hardwork. My father's work ethic for the last 35 years, in many ways, was the beacon that kept me going. Last, but definitely not the least, the role played by my family in helping this dissertation along cannot be over-stated. Nandini, my wonderful wife has made innumerable sacrifices both on the personal and professional front to accommodate my seven-day work schedule over the last five years. She shouldered a disproportionate amount of parenting responsibility without complaining. Janhvi, my lovely daughter is worthy of the highest praise for being the most understanding and 'mature four-year old' one could hope for. To my wife and daughter, I owe a ton of gratitude.

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CHAPTER I

INTRODUCTION

Interorganizational alliances are widely recognized as critical to product innovation. A notable trend is the rapid growth of new product development (NPD) alliances between large, well-established firms and small, growing firms. These alliances involving disparately sized firms are referred to as asymmetric alliances. In particular, in high technology markets, during 1970-1990, approximately 2300 asymmetric alliances were formed (Barley, Freeman, and Hybels 1991; Kogut and Kim 1991). Furthermore, the number of asymmetric alliances in high technology industries increased by over 250% during the 1990s (Cyr 2001).

In high-technology settings, larger, established firms seek R&D partnerships with smaller, growing firms because the latter are endowed with intangible resources and unique technological capabilities in niche areas (Chen and Hambrick 1995; Stuart 2000). Gomes-Casseres (1997) notes that although larger firms have been traditionally dominant players in the information technology and pharmaceutical industries, the advent of new technologies such as microelectronics and biotechnology presents unique opportunities for smaller entrepreneurial firms to pursue targeted innovation. Research on entrepreneurship (e.g., Eckhardt, Shane, and Delmar 2006) suggests that ties with larger firms are vital to the growth of smaller firms for at least two reasons.[1]

This dissertation follows the style and format of the *Journal of Marketing Research.*

[1] In this dissertation, the terms larger firms and smaller firms refer to differences in firm size.

First, smaller firms, being strapped for funds, use the alliances with larger firms to infuse the needed tangible resources for commercializing their new product development efforts. Second, partnerships with prominent partners such as larger, established firms buffers smaller firms from their liability of smallness, enhances their chances of survival, and boosts sales growth (Baum, Calabrese, and Silverman 2000; Stuart 2000). For instance, the stock price of Net2phone, a small Internet service provider, increased by 50%, following the announcement of a strategic NPD alliance with larger firms, Compaq and Sprint (*Business Week* 1999).

Typically, incumbent firms in high technology industries (e.g., pharmaceuticals, semiconductors, information technology) pursue multiple new product alliances with entrepreneurial firms to bolster their product pipelines. Managing multiple new product partnerships is a complex endeavor requiring incumbents to make numerous decisions periodically. One such decision pertains to pulling the plug on 'less promising' NPAs and diverting resources to other NPAs in the portfolio (Bordley 2003; Hauser, Tellis, and Griffin 2006). Marion Merell Dow, a pharmaceutical firm, entered into a 10-year agreement with Alteon in 1990 to develop and market *Pimagedine* and selected compounds. The scope of the 10-year agreement included R&D collaboration, $20M funding for Pimagedine's clinical development and provisions for the joint promotion and sale of the product in the U.S., Canada and Western Europe. However, Marion Merrell Dow ended its alliance with Alteon much before the completion of the ten year period. According to managers in Alteon, any termination other than an unanticipated failure of the product development program was never envisioned by the alliance partners (Van Brunt 1999). NPAs can be terminated for a number of reasons such as when partners have accomplished the objectives or when the NPA technology has failed. Yet, casual observation suggests that incumbents manage and balancing their portfolio by weeding out NPAs that do not fit its strategic objectives (Chan, Nickerson, and Owan 2007).

Given the proliferation of asymmetric new product development alliances in high-technology industries, it is important to understand how these alliances create or destroy value for the partnering firms. In addition to alliance formation, it is also important to understand the factors that influence the termination of asymmetric new product development alliances. The broad objectives of this dissertation are to assess the drivers of the financial gains or losses accruing to partnering firms from new product development alliances and the determinants of new product development alliance terminations.

CHAPTER II

FINANCIAL RETURNS FROM ASYMMETRIC NEW PRODUCT DEVELOPMENT ALLIANCES

OVERVIEW

Interorganizational alliances are widely recognized as critical to product innovation, particularly in high technology markets. Many new product development (NPD) alliances tend to be asymmetric, that is, they are formed between a larger firm and a smaller firm. These asymmetric alliances typically result in changes in the shareholder values of the partner firms. Are the changes in shareholder values of partner firms significant? Is the NPD alliance a win-win or win-lose partnership? Are they symmetric for the larger and smaller partner firms? What factors drive the changes in shareholder values of the partner firms? These important questions remain unexplored as there is little empirical research on the effect of NPD alliance on shareholder value and on the apportionment of this value between the partner firms. I develop and empirically test a model of short-term changes in shareholder values of larger and smaller firms involved in NPD alliances, using the event study methodology on data covering 167 asymmetric alliances in the information technology and communication industries. In this model, I examine alliance, firm, and partner characteristics as potential determinants of the changes in shareholder values of the partner firms due to a NPD alliance announcement. The model accounts for selection correction, potential cross-correlation across the residuals from the models of firm value changes for the larger and smaller firms, and unobserved heterogeneity. The results suggest that both the partners experience significant short-term financial gains, but there are considerable asymmetries between the larger and smaller firms with regard to the effects of alliance, partner and firm characteristics on the gains of the partner firms. The results relating to *alliance characteristics* suggest that while a broad scope alliance enhances the financial gains for the larger firm, a scale R&D alliance (relative to a link alliance) contributes positively to the financial gains for the smaller firm. With regard to *partner characteristics*, while partner alliance experience positively influences the financial gains for the larger firm, it has no significant effect on the financial returns for the smaller firm. Further, partner innovativeness is positively associated with the financial gains for the larger firm, but partner reputation is unrelated to the financial gains of the smaller firm. As regard *firm characteristics*, the magnitude of the financial gains accruing from a firm's own alliance experience is considerably higher for the smaller firm than it is for the larger firm.

INTRODUCTION

The outcomes of asymmetric alliances, particularly the changes in shareholder values of partner firms, may be different across the firms. It is important to use stock-market returns as an outcome measure for studying the impact of NPD alliances because shareholder value is a forward-looking metric (e.g., Bharadwaj, Bharadwaj, and Konsynski 1999; Houston and Johnson 2000; Kumar, Ramaswami, and Srivastava 2000). A small body of literature has examined changes in the shareholder values of firms in partnerships involving disparately sized firms, albeit not in the context of new product development. For instance, evidence from the mergers and acquisitions (M&A) literature suggests that the acquired firm (the smaller firm) and the acquiring firm (the larger firm) experience positive and negative short-term abnormal returns, respectively (Asquith 1983). Prior research on inter-firm partnerships in general (not in the NPD context) and firm value (Alvarez and Barney 2001; Chan et al 1997; Das, Sen, and Sengupta 1998; Koh and Venkatraman 1991; McConnell and Nantell 1985) suggests that while strategic alliances do create value for firms, there is lack of consensus on the division of financial gains between larger and smaller partners. In many cases, much of the economic value created between smaller/entrepreneurial and larger firms is appropriated by the larger partner (Alvarez and Barney 2001). Examining a sample of 60 joint ventures, McConnell and Nantell (1985) observe that the investors in the smaller firm, on average, receive larger abnormal returns, but the absolute gains in shareholder value for both partners are more or less equivalent. Likewise, Chan et al. (1997) conclude that while smaller partners experience larger abnormal returns than larger partners, the magnitudes of the absolute gains are roughly equal. In contrast, in an analysis of 60 non-equity alliances from the information technology sector, Koh and Venkatraman (1991) point out that on average, the smaller partner gains substantially ($19.2 million) more than the larger partner ($2.3 million). An analysis of the cumulative abnormal returns of 50 firms involved in strategic alliances reveals that the gains to the smaller firm exceed those to the larger partner firm (Das, Sen, and Sengupta 1998). The divergent results in prior studies can be attributed to heterogeneity in the focus of alliance agreements (e.g., R&D or NPD, marketing, and licensing). Not much is known about how NPD alliance affects the changes in the shareholder values of the partner firms and whether they are asymmetric.

More importantly, despite the recognition that an understanding of the factors contributing to the financial gains in such asymmetric alliances is beneficial to scholars and managers (Koh and Venkatraman 1991; McConnell and Nantell 1985), not much is known about the drivers of the financial gains for the partner firms. In particular, very little is known about differences in the drivers of financial returns to larger and smaller firms in a NPD alliance. This dissertation seeks to fill this research gap.

Are the changes in shareholder values of the partner firms in an asymmetric NPD alliance announcement significantly positive or negative? Are the gains in a NPD alliance symmetric between the larger and the smaller partner firms? What are the determinants of the changes in shareholder values of the partner firms in an NPD alliance? The answers to these questions are important for both larger and smaller firms to better select their partners, the scope and type of alliance, and the resources to be allocated for new product development. The objective of this paper is to develop and empirically test a model of factors influencing the creation/erosion of shareholder values of partner firms following the announcement of asymmetric NPD alliances.

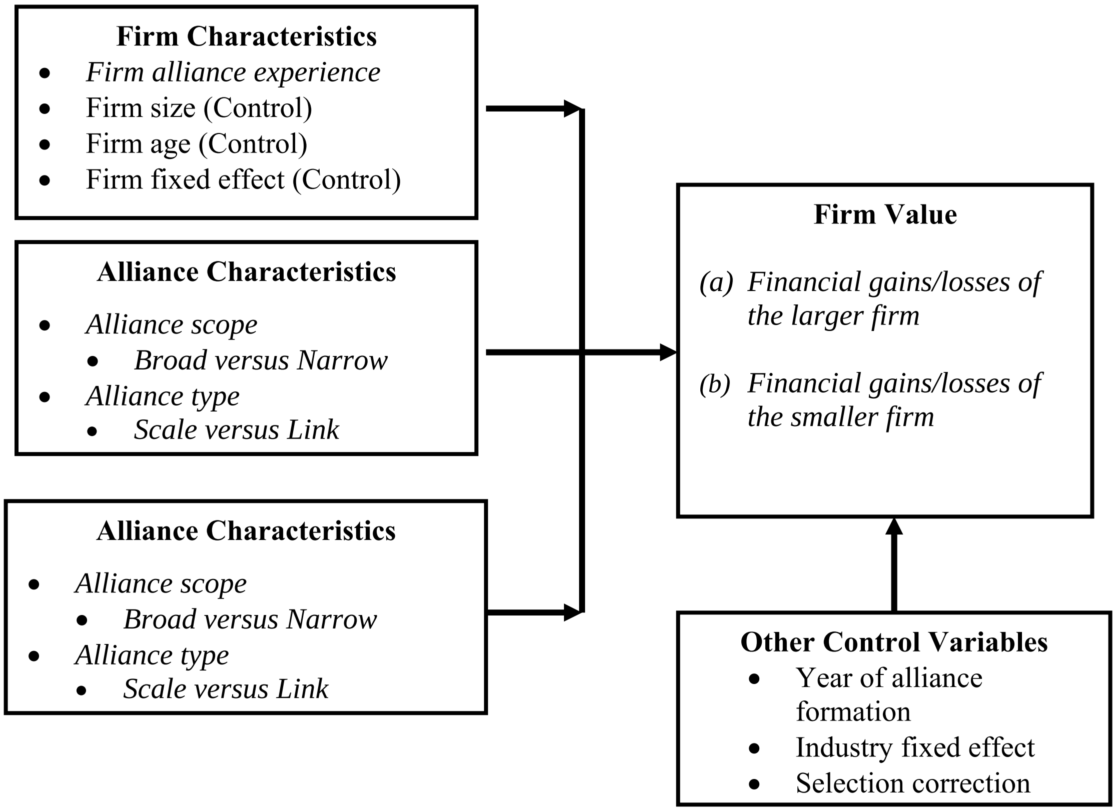
To address these important research questions, I follow a three-step process. First, I develop a conceptual framework of the major determinants of the changes in shareholder values of partner firms in a NPD alliance. Second, I use the event study approach to determine the short-term changes to shareholder value that accrue to larger and smaller firms after a NPD alliance is announced. Third, I estimate a model comprising the effects of firm, alliance, and partner characteristics on shareholder value changes for larger and smaller firms in a NPD alliance using data from 167 asymmetric NPD alliances in the information technology and communication industries.

This study contributes to the literature on NPD alliances in at least two distinct ways. First, to my knowledge, this study is the first to examine factors affecting the financial gains of *both* larger and smaller firms in a NPD alliance. In doing so, I seek to address concerns expressed in the literature regarding the limitations of focusing on the performance of one of the two firms in a partnership (e.g., Wuyts, Stremersch, and Dutta 2004). Second, much prior empirical research examining the impact of alliances on firm performance has focused exclusively on either alliance characteristics (Bucklin and Sengupta 1993; Chan et al 1997; Wuyts, Stremersch, and Dutta 2004), or firm characteristics (Anand and Khanna 2000; Chan et al 1997; Johnson, Sohi, and Grewal 2004), or partner characteristics (Baum, Calabrese, and Silverman 2000; Stuart 2000). I extend the literature by rigorously developing and empirically testing a model that links all three types of factors (i.e., firm, alliance, and partner characteristics) to changes in the partner firms' shareholder values in a single framework focused on NPD alliances. The model accounts for selection correction, potential cross-correlation across the residuals from the models of firm value changes for the larger and smaller firms, and unobserved heterogeneity.

CONCEPTUAL FRAMEWORK AND RESEARCH HYPOTHESES

Figure 1 presents a conceptual model delineating the factors influencing the creation or erosion of partner firms' values in asymmetric NPD alliances. An exogenous event such as the formation of an alliance is likely to change a firm's asset price through a change in the anticipated cash flows as well as change in the discount rate associated with the firm's future cash flows (Schwert 1981). I expect firm characteristics (alliance experience), alliance characteristics (alliance scope and alliance type) and partner characteristics (partner alliance experience, partner reputation, and partner innovativeness) to be the major determinants of changes to the net present value of each partner firm in a NPD alliance. I develop hypotheses about the effects of the potential drivers of shareholder value creation in a NPD alliance. Although not all hypotheses focus on asymmetries between the larger and smaller firms, the intent is to examine the differences between the partner firms in the results of the tests of the hypotheses.

FIGURE 1
FIRM VALUE CREATION/EROSION IN ASYMMETRIC NEW PRODUCT DEVELOPMENT ALLIANCES: A CONCEPTUAL MODEL



Firm Characteristics

Firm alliance experience. A firm's alliance experience exposes it to rich combinations of processes, inputs and outcomes and enables it to better adapt to contingencies as well as acquire new related knowledge. Previous alliance experience may enhance the stock market performance of the firm involved in a NPD alliance in at least two ways (Anand and Khanna 2000; Sampson 2005). First, firms with alliance experience learn to better manage complex new alliances through the establishment of a general alliance management capability and inter-organizational routines that aid in partner selection and conflict management (Ireland, Hitt, and Vaidyanath 2002; Kale, Dyer, and Singh 2002). Second, firms accumulate valuable technological and product-market knowledge from past alliances that enable them to be more successful in a new NPD alliance.

Although alliance experience is likely to have a positive impact on the financial gains accruing to both larger and smaller firms, I expect the gains to accrue to these partner firms through different mechanisms. Because more public information is typically available for larger firms than for smaller firms, investors know more about the strategies of larger, well-established firms than about smaller firms. Therefore, while past alliances by a larger firm may not provide radically new information to investors, they provide information about the larger firm's experience in accessing intangible resources and reduce investor uncertainty about the new alliance through a decrease in the larger firm's risk profile (i.e., discount rate), resulting in a higher firm value. For a smaller firm, its past alliances with other firms provide information about its accessibility to tangible resources and social capital, which yields additional cash flows as well lowers its risk profile (see Baum, Calabrese, and Silverman 2000; Stuart 2000 for reviews). Ability to work with partners is a specific competence that plays an important role in an entrepreneur's success (Baron 2000) and thus the smaller firm's value. I summarize the arguments through the following hypothesis.

H_1: The greater the alliance experience of a firm in a NPD alliance, the greater the financial gains to that firm.

Alliance Characteristics

*Alliance scope (Broad vs. Narrow).*The scope of the NPD alliance may influence the change in firm value. Alliance scope refers to the breadth of functional activities (e.g., R&D, manufacturing, marketing, and distribution) that the partners agree to undertake during the tenure of the alliance (Doz and Hamel 1998; Varadarajan and Cunningham 1995). Alliance scope can be construed as a proxy for the pre-commercial value of the alliance, which the investor community uses to estimate the future revenue streams of the firms. Broad scope alliances are likely to generate more revenues and financial gains than narrow scope alliances for at least two major reasons. First, an alliance that encompasses many functional areas of collaboration signals a greater financial potential than one that covers only a few areas. Second, a broad scope alliance also indicates greater commitment by the partners toward the alliance than does a narrow scope alliance.

Despite this wisdom regarding the benefits of broad scope NPD alliances, narrow scope NPD alliances are quite common in high technology industries. Firms in the information and communication equipment (ICE) industries routinely limit the scope of NPD alliances to prevent the loss of technological knowledge to partners competing in overlapping product-markets (Oxley and Sampson 2004). Likewise, theory and evidence from the biopharmaceutical industry suggests that because the threat of knowledge spillovers and technology appropriation are higher in broad and complex alliances than they are in narrow scope alliances, the larger firm (i.e., pharmaceutical partner) is likely to corner a greater proportion of the revenues than the smaller firm (i.e., biotechnology partner) (Alvarez and Barney 2001; Lerner and Merges 1998; Veugelers and Kesteloot 1996). Therefore, I expect the larger firm to benefit more from broad scope NPD alliances than from narrow scope NPD alliances because a broad scope alliance provides the large firm with greater opportunity for private gains, whereas a narrow scope alliance restricts the magnitude of such gains. For the smaller firm, however, any benefit from a broad scope alliance may be offset by the need to have a narrow and restrictive scope to protect misappropriation of R&D assets and leakage of knowledge (Li, Eden, Hitt, and Ireland 2005). Therefore, instead of offering a formal hypothesis on this relationship for the smaller firm, I treat it as an empirical issue for subsequent investigation.

> H_2: The broader the scope of a NPD alliance, the greater the financial gains to the larger firm.

*Alliance type (Scale vs. Link).*Partnerships between firms in a NPD alliance involve the pooling or exchange of firm-specific resources, leading to two types of NPD alliances, scale alliance and link alliance (Hennart 1998). Scale alliances refer to partnership deals in which resources are pooled for activities in the same stage(s) of the value chain, which in the case of an NPD alliance, is the R&D stage. Link alliances refer to partnership deals in which resources are exchanged for activities performed at different stages of the value chain. From the standpoint of exchange of resources, R&D and marketing are two stages that are important in the innovation process (Song and Thieme 2006).

Asymmetric alliances are somewhat unstable because they exacerbate learning asymmetries, resulting in the larger firm often ‘finishing’ learning before the smaller firm (Doz and Hamel 1998). The extent to which firms have the opportunity to engage in learning races, however, varies by the type of alliance. Dussuage, Garrette, and Mitchell (2000) note that deals in which resources are exchanged (link) tend to produce more asymmetric outcomes than deals in which resources are pooled (scale). In general, in link alliances involving NPD, the smaller firm contributes resources to upstream activities (e.g., R&D) and the larger firm contributes resources to downstream activities (e.g., manufacturing, marketing, distribution). Failure to gain expertise in downstream activities could be detrimental to the long-term survival of the smaller firm as it diminishes its chances of independently commercializing its innovations in the future. The reasoning is similar to that advanced by Hitt et al. (2000) for the greater preference of complementary capabilities in alliances by developed market firms (typically larger firms) over emerging market firms (typically smaller firms). As a result, I expect the balance of power to shift toward the larger partner in link alliances.

In contrast, a scale alliance shifts the balance toward the middle because both the partners agree to pool resources for R&D and possibly, manufacturing and marketing, thereby providing the smaller firm with greater access to resources and technical know-how. This argument is consistent with empirical evidence from the biopharmaceutical sector, which suggests that more control rights (e.g., patents) from technology alliances are assigned to the smaller firm (i.e., the R&D-intensive firm) than they are to the larger firm (i.e., the client firm) when the smaller firm is in a better bargaining position (as reflected by its strong equity market value) (Lerner and Merges 1998). Therefore, I expect the smaller firm to benefit more when it contributes greater resources to the different stages of NPD and stakes a greater claim to the residual rights from product innovation. In addition, from the smaller partner's viewpoint, the possibility of the larger partner prematurely exiting the alliance is lower in scale alliances because of the greater involvement of the larger partner in upstream NPD activities (i.e., R&D). These arguments suggest that smaller firms are likely to benefit more from scale alliances, whereas larger firms are likely to gain more from link alliances.

H_{3a}: The financial gains to the larger firm in a NPD alliance will be greater for link alliances than they are for scale alliances.

H_{3b}: The financial gains to the smaller firm in a NPD alliance will be greater for scale alliances than they are for link alliances.

Partner Characteristics

Partner alliance experience. In addition to own alliance experience, the alliance experience of its partner firm can play an important role in determining changes in the shareholder value of a firm. Consider first the changes in the value of the larger firm. In choosing its smaller partner firm, the larger firm is typically faced with an adverse selection problem because of information asymmetries with respect to the quality of smaller firms (Shane, Shankar, and Aravindakshan 2006). The alliance experience of a smaller partner is likely to benefit the larger partner. Although, the larger firm may not have had any previous alliance with the smaller firm, the social networks of the larger firms with prominent firms with whom the smaller firm has ties or prior experience, could provide valuable insights about the quality of the smaller partner. In addition, I expect the effect to be positive in the NPD context because the stock market is more likely to respond favorably when the larger firm partners with the smaller firm possessing greater NPD alliance experience. The partner alliance experience serves to reduce the uncertainty regarding the NPD effort. As a result, I advance the following hypothesis.

H_{4a}: The greater the smaller firm's alliance experience, the greater the financial gains to the larger firm in a NPD alliance.

The partner's alliance experience will likely have a positive effect on the financial gains to the smaller firm as well. Alliance outcomes for a focal firm are positively impacted by learning through their direct experience as well as by the experience of their alliance partners (Sarkar, Echambadi, and Ford 2003). Thus, the smaller firms could benefit from the experience of larger partners as it provides them the opportunity to mimic their alliance management techniques (e.g., process routines to initiate, manage, and terminate alliances [Johnson, Sohi, and Grewal 2004]). Therefore, I expect the effect to be positive because the stock market is likely to be better informed about the strategies of larger firms with higher R&D alliance experience than about larger firms with little experience in managing complex NPD alliances. As a result, I advance the following hypothesis:

H_{4b}: The greater the larger firm's alliance experience, the greater the financial gains to the smaller firm in a NPD alliance.

Partner reputation. Reputation refers to a global perception of the extent to which an organization is held in high esteem or regard by its key constituents on the basis of its past actions and future appeal (Fombrun and Shanley 1990). Firms contemplating alliances assess potential partners on reputation (Baum, Calabrese, and Silverman 2000; Shane, Shankar, and Aravindakshan 2006; Stuart 2000). In general, the quality (e.g., of products and management) of smaller firms is uncertain because few indicators of their key constituents (e.g., customers, suppliers, collaborators, and investors) are available to assess their track record. Partnering with reputed larger firms provides several benefits to smaller firms. First, an alliance with a larger firm generally draws the attention of the key constituents to the new venture and the smaller firm (Stuart 2000). Second, the fact that a reputed larger firm has selected a smaller and lesser-known entity over alternative firms provides a valuable endorsement for the smaller firm (Stuart 2000). Third, alliance with a reputed firm provides access to valuable skills and resources (e.g., product-market capital and social capital) that the smaller firm lacks. Because larger firms do not typically enter into asymmetric alliances with smaller firms to derive reputation benefits, there is no hypothesis offered for the effect of partner reputation on changes in shareholder values for larger firms. Based on these arguments, I expect the performance of smaller firms to be enhanced in their alliances with reputable larger firms, leading to H_5.

> H_5: In a NPD alliance, the financial gains to the smaller firm are greater when its larger partner firm has a higher reputation.

Partner innovativeness. While smaller firms can benefit from the reputation of larger partner firms, larger firms could dilute their reputation by partnering with smaller, low-quality firms. Small, young firms, by definition, have little or negligible reputation due to their relatively short track record. Yet, they are attractive alliance NPD partners to larger firms because of their expertise in niche areas of technology, especially in industries where the locus of innovation lies more outside than inside the firm. Prior studies suggest that while larger firms are bestowed with innovation advantages in mature industries, smaller firms tend to innovate more in growing industries characterized by the absence of a standardized product. Acs and Audretsch (1988) note that while larger firms tend to be more innovative in industries with imperfect competition, smaller firms are more innovative in industries with perfect competition. Smaller firms with their innovative capabilities in niche areas enable larger firms to overcome their structural inertia and technological rigidity. A larger firm can learn from a smaller firm and enhance its performance in a NPD context (Rothaermel 2001). Based on the preceding arguments, I expect the performance of larger firms in high technology industries to be higher when partnering for NPD with innovative smaller firms than with non-innovative smaller firms. Because smaller firms do not typically enter into asymmetric alliances with larger firms to gain from the larger firm's innovativeness, I do not expect an effect of partner innovativeness on the financial gains for smaller firms. I expect the smaller firm to gain mainly through the transfer of social capital (e.g., reputation) than through their larger partner's innovativeness.

> H_6: In a NPD alliance, the financial gains to the larger firm will be greater when the smaller partner firm is more innovative.

In addition to these focal variables, I also expect control variables such as firm size, firm age, year of alliance announcement, industry-specific and firm-specific characteristics to impact the changes in the value of the partner firms in a NPD alliance. The operationalization of these variables and their effects on changes in firm values are discussed subsequently.

DATA

I test the hypotheses in an empirical setting comprising two broad industries that exhibit several asymmetric alliances, namely, the information technology and telecommunication industries. Data on NPD alliances between firms in these industries were drawn from the joint ventures/alliances database of the Securities Data Company (SDC). Specifically, the sample comprised firms in the computer and office equipment (i.e., SIC codes 3571, 3572, 3575, 3577, 3578, and 3579), prepackaged software (i.e., SIC code 7372), and communications equipment (i.e., SIC codes 3661, 3663, and 3669) industries that entered into R&D alliances between January 1993 and September 2004.

The selection of this time period was influenced by the observation that SDC did not track all deals by U.S. firms during the period 1990-1992 because of inadequate corporate reporting requirements (Anand and Khanna 2000). Therefore, the starting date for data collection was January 1993. The second sampling requirement was to identify alliances in which both firms were publicly traded U.S. firms.[2] The third sampling requirement was to only include non-equity alliances. This was necessary because equity alliances could potentially be an intermediate step for the larger firm to acquire the

[2] It is worth noting that resource scarcity and information asymmetry problems in publicly held small firms may not be as severe as they are in privately held small firms. However, even small publicly held firms are faced with problems of survival. In addition, given that it is almost impossible to objectively assess the performance of privately held firms, focusing on small public firms is the only practical approach to empirically test our hypotheses.

smaller firm, and therefore the stock market could potentially be responding to the smaller firm's potential as an acquisition target.

The fourth sampling requirement was to identify alliances with considerable size asymmetries. The lack of prior research in this area made it necessary to empirically define the cut-off point for size differences. Prior research has operationalized firm size as assets or sales or number of employees. In this study, I operationalize firm size in terms of the assets of the firm in millions of dollars.[3] To better examine asymmetry in NPD alliances, I consider only those alliances in which the ratio of the larger firm's assets to that of the smaller firm is greater than five. Table 1 provides the frequency distribution of asymmetric R&D alliances involving publicly traded firms between 1993 and 2004. There were no asymmetric alliances recorded during 1996. The size ratio exceeded 10 in approximately 85% of the alliances, reflecting considerable size asymmetries in the sample.

[3] Subsequent alternate operationalizations of firm size in terms of sales and number of employees yielded substantively identical results with regard to size asymmetries in alliances.

TABLE 1
DISTRIBUTION OF NPD ALLIANCES BY SIZE ASYMMETRY

Size Ratio	Number	Percentage
5.0-6.0	9	5.39
6.1-8.0	7	4.19
8.1-10.0	10	5.99
10.1 and above	141	84.43
Total	167	100.00

The sample attrition criteria yielded 222 dyadic relationships between a larger firm and a smaller firm. I checked the accuracy of the NPD alliance announcement date, the most critical aspect of the event study methodology using Lexis-Nexis.[4] I eliminated 19 observations because of uncertainty about the announcement date. In the remaining cases, the SDC announcement date did not differ from the announcement dates provided by Lexis-Nexis. Additional checks for concurrent events (e.g., announcement of quarterly results, announcement of new product introductions, and changes in executive positions) around the 3-day window surrounding the announcement resulted in the elimination of 36 announcements that could potentially confound the results. The accuracy and confounding event check procedures yielded a final sample of 167 dyads.

[4] Although the SDC database on alliances is by far, the most comprehensive source of information on alliance agreements, the dates are occasionally misreported in the database (Anand and Khanna 2000). In some cases, the database reports the date on which negotiations for the alliance began, whereas in other cases, it reports the date on which the alliance was signed. In addition, observations on a single agreement mistakenly appear more than once.

This sample size compares well with those in studies that have used the event study methodology (Srinivasan and Bharadwaj 2003), offering sufficient statistical power to test the hypotheses. I collected the measures of firm size and market capitalization from the Compustat database.

A sample of description of the NPD alliances in the data appears in Table 2. The larger firms ranged from Microsoft to Lucent Technologies. The smaller firms included Shiva Corp., Documentum, Inc. and Xylan Corp. Some of the NPD alliances explicitly included marketing agreements as well.

TABLE 2
SAMPLE OF ASYMMETRIC NPD ALLIANCES

Larger Firm	Smaller Firm	New Product Alliance Details
Microsoft Corp.	Wang Laboratories	Development and marketing of Windows NT versions of imaging and workflow server products
Oracle Corp.	i2 Technologies	Joint development of a supply chain optimization solution
International Business Machines (IBM)	Xylan Corp.	Development, manufacturing and marketing of network switches
Motorola Corp.	Shiva Corp.	Development of an enhanced version of Motorola 925 system for the remote access market.
Hewlett-Packard	Skytel Corp.	Development and marketing of wireless marketing solutions for palm-top computers
Digital Equipment Corp.	Spire Technologies	Joint development and marketing of an application programming interface software
Lucent Technologies	Novatel Wireless	Development of next generation multi-mode, multi-band wireless data products

MEASURES AND METHODOLOGY

Table 3 provides a summary of the variables and their operationalization.

TABLE 3
VARIABLE OPERATIONALIZATION AND DATA SOURCES: STUDY ONE

Variable	Operational Measure	Data Source(s)
Net present value	Cumulative short-term abnormal returns x Market capitalization 20 days prior to the announcement	Center for Research in Security Prices (CRSP)
Alliance experience	Number of alliances entered by the firm from 1993 including the current alliance	Securities Data Company (SDC), Lexis Nexis
Alliance scope	Number of functional areas in which the partners agree to cooperate	SDC, Lexis Nexis
Alliance type		SDC, Lexis Nexis
• Scale	If the alliance agreement states that the activities are undertaken jointly by the partners *Example*: "Sun Microsystems Computer Corp, a unit of Sun Microsystems, Inc. and Ancor Communications, Inc. have agreed to jointly develop and market the industry's first switched fiber channel attachment to a disk storage array."	
• Link	If the alliance agreement states that the activities are exchanged between the partners *Example:* Lucent Technologies and Novatel Wireless have entered into a strategic alliance to develop the next-generation high tech wireless products that will allow users to access mobile users to access the Internet and corporate networks over the 3G universal mobile telecommunications system network. According to the terms of the agreement, Novatel was to develop multi-mode multi-band UMTS/GPRS wireless PC card modems while Lucent was to contribute marketing support."	
Partner reputation	8-item scale	Fortune Magazine Database
Partner innovativeness	No. of patents citations received by the firm in the five years prior to the current alliance	United States Patent and Trademark Office (USPTO)
Firm size	Logarithm of firm assets	Compustat
Firm age	Number of years from the founding date to the date of the current alliance	Mergent Online/Lexis Nexis
Macroeconomic condition (used in computation of selection correction, λ)	30-day U.S. treasury bill return	CRSP

Focal Variables

Net present value. The dependent measures of this study are the financial gains/losses or the net present value of the NPD announcement accruing to the partner firms. I computed financial gains as the product of short-term cumulative abnormal returns in the event window of (-1, +1) and the market capitalization of the firm 20 days before the alliance announcement, consistent with Chan et al (1997). The choice of financial gains/losses over short-term abnormal stock returns as the measure of the dependent variable was influenced by the following consideration. Short-term cumulative abnormal returns vary with firm size (Anand and Khanna 2000). That is, larger firms tend to have smaller cumulative abnormal returns and smaller firms tend to have greater cumulative abnormal returns. Therefore, the use of total financial gains/losses as the measure alleviates the scale problem associated with cumulative abnormal returns.

I use the event study methodology to assess the abnormal returns accruing to firms entering into NPD alliances. I estimated the daily stock returns for every firm in the sample over a 240-day period prior to the event day using the market model (Brown and Warner 1985). The short-term return event study methodology rests on the assumption of efficient markets. That is, the market has sufficient information to gauge the effectiveness of a firm’s NPD alliance. Although concerns have been voiced regarding the validity of the assumption, prior research in strategic alliances has explicitly tested the efficient market hypothesis and shown that the short-term abnormal returns to alliance announcements are strongly correlated with firm performance as reported by managers (see Kale, Dyer, and Singh 2002; Koh and Venkatraman 1991 for reviews).

The NPV of the firm following the NPD alliance announcement is computed using the market model for the event study (see Appendix 1 for details).

Alliance experience. This measure is constructed as a count of the number of alliances in which the firm was involved from the beginning of 1993 until (and including) the focal alliance.[5] It is worth noting that this count measure does not distinguish between different types of alliances such as narrow scope and broad scope alliances. However, this is not likely to be a concern because firms are likely to learn how to coordinate across organizational boundaries, select appropriate contract structures, and evaluate performance even in the case of narrow scope alliances (Sampson 2005). This count measure also does not distinguish between prior alliances that were successful and those that were unsuccessful, but because firms tend to learn from both successes and failures, this issue is not a problem as well.

Alliance scope. I operationalize alliance scope in terms of the number of functional activities covered in the alliance. For example, I coded an alliance involving cooperation in a single functional area as one and an alliance involving cooperation in R&D, manufacturing, and marketing as three.

Alliance type. I operationalize scale alliances in terms of the nature of the contribution made by alliance partners. I coded alliances in which firms jointly contributed resources to the NPD stage of the value chain as scale alliances, whereas alliances in which firms

[5] The measure of firm alliance experience is left censored (i.e., alliances entered into by firms prior to 1993 are ignored) and this could potentially introduce measurement error into this variable. From a practical standpoint, however, this measure is reasonable, given that asymmetric alliances by firms in information technology and telecommunication industries began gathering momentum only in the early 1990s (Dalziel 2001). Nevertheless, I subsequently estimated the model using an alternate measure, namely, total of past alliances (including those before 1993 all the way until 1985 for which, data were available). The substantive results remained unchanged.

contributed resources to different stages of the value chain as link alliances was coded as link alliances. For instance, I coded alliances in which firms jointly developed products as scale alliances and alliances in which one firm contributed all the R&D resources and the other firm contributed all the marketing resources as link alliances.

Partner reputation. Measures of firm reputation for the partners during 1993-2004 were obtained from the list of America's most admired companies published by *Fortune*. *Fortune's* annual survey rates firm reputation on a 11 point scale (0 denoting poor and 10 denoting excellent) on eight characteristics, long- term investment value, financial soundness, wise use of corporate assets, quality of management, quality of products/services, innovativeness, ability to attract, develop, and keep talented people, and community and environmental responsibility. I use this measure because it is a valuable source for such a rich and abstract concept (see Fombrun and Shanley 1990; Houston and Johnson 2000).

Partner innovativeness. The innovativeness of the partner firm was captured through a count of the patents citations received by the partner firm in the five years prior to the focal alliance date. I collected the data on patents filed by firms from the United States Patent and Trademark Office (USPTO) database. The USPTO provides detailed information on patents filed by information technology and telecommunication firms from the beginning of 1975. The innovation literature argues that a patent citation count measure is a better indicator of the technological position of the firm than R&D intensity (Griliches 1990) and has been widely used in prior research to measure innovation output (Acs and Audretsch 1988; Bound et al 1984).

Control Variables

Firm size. Consistent with prior studies (Stuart 2000), I control for the size of the firm by using the logarithm of the asset value of the firm at the time of the NPD alliance. The asset value of the firm was obtained from the Compustat database.

Firm age. I operationalize firm age as the time elapsed from the date of founding of the firm to the date of announcement of the NPD alliance. The founding date of the firm was retrieved from the Mergent/Lexis Nexis databases. Controlling for firm age is necessary to ensure that the changes in firm values upon a NPD alliance announcement are not a consequence of aging and maturation of the partner firms.

Year of alliance formation. To control for differences in financial gains among the firms due to relevant economic and business conditions in the year in which the alliance was formed, I use dummy variables for the years to capture these effects.

Industry fixed effect. To control for variance in financial gains due to industry-specificity (Kumar et al. 2000), I use dummy variables for the industry to which the focal firm belongs.

Firm fixed effect. To control for variance in firm financial gains due to firm-specific characteristics, I use dummy variables for firms involved in multiple alliances in the dataset.

Selection correction. A potential econometric issue in estimating changes in shareholder value created by firm strategies or events is the bias that could arise on account of sample selection. In general, sample selection bias can occur when the criterion for selecting the observations is not independent of the outcome variables. In this study, I observe that larger firms enter into asymmetric alliances more than smaller firms do during a given time period. Therefore, models that do not account for the sample selection and attrition processes could potentially result in biased predictor estimates (Greene 2002; Shane, Shankar, and Aravindakshan 2006). To obtain unbiased estimates, I use Lee's (1983) generalization of a Heckman selection correction model that uses predicted probabilities for firm failure to generate a selection correction variable, λ given by:

$$\lambda_{kt} = \phi[\Phi^{-1}(F_k(t))]/(1 - F_k(t)) \qquad \textbf{(1)}$$

where $F_k(t)$ is the cumulative hazard function for firm k at time t, ϕ is the standard normal density function and Φ^{-1}, the inverse of the standard normal distribution function (Lee 1983).

The rate of alliance formation has been observed to be a function of the macroeconomic conditions for the business involved. That is, firms tend to form more alliances during periods of economic growth than during periods of economic decline (Park, Chen, and Gallagher 2002). Following Audretsch and Mahmood (1995) who explicitly examined the link between macroeconomic conditions and business cycles, I use the 30-day US treasury bill interest rate to compute the predicted probability of observing the event (i.e., asymmetric NPD alliance). I then include the selection correction term, λ_{kt}, as a regressor in the model that captures firm value created through asymmetric NPD alliances.

Model Development

Tests of hypotheses H_1 to H_6 entail analysis of 167 alliances involving 75 larger firms and 150 smaller firms in the data. I develop two equations, one for the larger firm and the other for the smaller firm. The dependent variable in both the equations is the change in the shareholder wealth or net present value created by the NPD alliance. The explanatory variables are the focal and control variables. The system of equations is given by:

$$NPV_i = \beta_0 + \beta_1 FALEXP_i + \beta_2 ASCOPE_i + \beta_3 ATYPE_i + \beta_4 PALEXP_i + \beta_5 PINNOV_i + \beta_6 FSIZE_i + \beta_7 FAGE_i + \beta_8 \lambda_i + \sum_{p=1}^{P-1} \beta_{9p} IND_{pj} + \sum_{r=1}^{9} \theta_r YEAR_{ri} + \sum_{m=1}^{M-1} \gamma_m F_m + \varsigma_i \quad \textbf{(2)}$$

$$NPV_j = \gamma_0 + \gamma_1 FALEXP_j + \gamma_2 ASCOPE_j + \gamma_3 ATYPE_j + \gamma_4 PALEXP_j + \gamma_5 PREP_j + \gamma_6 FSIZE_j + \gamma_7 FAGE_j + \gamma_8 \lambda_j + \sum_{q=1}^{Q-1} \gamma_{9q} IND_{qj} + \sum_{r=1}^{9} \phi_r YEAR_{rj} + \sum_{n=1}^{N-1} \delta_n F_n + \omega_j \quad \textbf{(3)}$$

where, i is the larger firm, j is the smaller firm,

NPV_i = Change in the shareholder wealth,

FALEXP = Cumulative number of alliances entered into by the focal firm including the current alliance,

ASCOPE = Number of functional areas covered in the alliance,

ATYPE = 1 for scale alliance, 0 for link alliance,

PALEXP = Cumulative number of alliances entered into by the partner firm including the current alliance,

PINNOV = Cumulative number of patent citations received by the alliance partner firm in the five years prior to the current alliance,

PREP = Mean value of eight-items on a survey of the reputation of the alliance partner firm,

FSIZE = Logarithm of firm assets,

FAGE = Number of years from the firm's inception date until the date of the current alliance,

$\lambda =$ selection control variable for the firm,

IND = Dummy variable for the industry to which the focal firm belongs,

$YEAR_r$ = Dummy variable for the year r, r ε {1,2,..9, each representing years 1994 through 2004, 1993 is the base year, no alliance in 1996}, = 1 if r is the year in which the NPD alliance is announced, 0 otherwise,

F = Dummy variable for each firm involved in multiple alliances in the data period,

P = Number of industries represented by larger firms = 7,

Q = Number of industries represented by smaller firms = 10,

M = Number of larger firms with multiple alliances in the data period,

N = Number of smaller firms with multiple alliances in the data period, and

$\varsigma, \omega =$ Error terms.

Model Estimation

Because the financial gains of the larger and smaller firms are generated from the same alliance, the system of equations could be correlated through their residuals. Using a standard Breusch-Pagan Lagrange Multiplier (LM) test, the null hypothesis of independent residuals across equations ($\chi^2 = 25.45$, $p < 0.001$) was rejected. Therefore, seemingly unrelated regression (SUR) estimates of the system of two equations are more efficient than ordinary least squares (OLS) estimates are, so I estimate the system using SUR (Zellner 1962). Because the same firm may be involved in more than one NPD alliance, to control for unobserved firm heterogeneity, I use the fixed effects approach (operationalized by dummy variables), consistent with Shane, Shankar, and Aravindakshan (2006). Based on the number of multiple alliances found in the data, I include 11 firm fixed effects for the larger firm equation and three firm fixed effects for the smaller firm equation.

RESULTS

Tables 4 and 5 provide the descriptive statistics and the correlation matrices for the variables used in the study. From these tables, it is evident that there is considerable variance in firm value changes, the dependent measures for the study. The tables also suggest that the correlations between the independent variables in the equations are relatively small, the condition indexes are reasonable, and the variance inflation factors (VIF) are less than 10, alleviating concerns about potential multicollinearity.[6]

[6] The correlations relating to the industry dummies are not shown for lack of space. They are, however, quite small, alleviating any concerns of potential multicollinearity.

TABLE 4
CORRELATION MATRIX FOR LARGER FIRMS

	Mean	Std. Deviation	NPV	FALEXP	SCOPE	TYPE	PALEXP	PINN	FSIZE	FAGE	λ	Y94	Y95	Y97	Y98	Y99	Y00	Y01	Y02	Y03
NPV	50,722	145,875	1																	
FALEXP	4.40	4.92	0.45	1																
SCOPE	0.57	0.04	0.13	0.00	1															
TYPE	0.41	0.04	0.06	0.00	0.24	1														
PALEXP	1.22	0.52	0.16	0.05	0.14	-0.01	1													
PINN	16.14	49.93	0.11	0.18	-0.01	0.01	0.00	1												
FSIZE	3.96	0.80	0.11	0.59	0.00	0.08	0.16	0.04	1											
FAGE	44.58	33.89	-0.07	0.35	-0.10	-0.02	0.08	-0.08	0.63	1										
λ	1.38	0.02	-0.11	-0.13	0.02	0.22	-0.07	-0.06	0.00	0.08	1									
Y94	0.02	0.01	-0.07	-0.09	0.05	0.01	-0.05	-0.04	-0.16	0.04	0.07	1								
Y95	0.04	0.01	-0.13	0.23	-0.08	0.06	-0.03	0.19	0.06	0.06	0.14	-0.02	1							
Y97	0.06	0.02	0.26	-0.00	0.05	0.12	0.00	-0.07	-0.05	-0.17	-0.17	-0.04	-0.03	1						
Y98	0.04	0.01	0.19	0.09	-0.05	0.09	-0.02	-0.10	-0.05	0.00	-0.05	-0.03	-0.03	-0.05	1					
Y99	0.10	0.02	0.09	0.17	-0.04	-0.15	0.14	0.04	0.03	-0.02	-0.01	-0.05	-0.05	-0.07	-0.07	1				
Y00	0.14	0.03	0.04	0.09	0.04	-0.21	-0.07	-0.04	-0.11	0.04	-0.23	-0.07	-0.06	-0.10	-0.09	-0.14	1			
Y01	0.10	0.02	0.00	0.02	-0.06	-0.07	-0.07	-0.10	0.02	0.01	-0.08	-0.05	-0.04	-0.07	-0.06	-0.11	-0.13	1		
Y02	0.23	0.03	-.02	-0.06	0.00	-0.07	0.06	0.17	0.14	-0.04	-0.20	-0.10	-0.09	-0.14	-0.13	-0.20	-0.25	-0.19	1	
Y03	0.12	0.03	-0.13	-0.11	0.06	0.10	0.11	-0.07	0.02	0.07	0.19	-0.06	-0.04	-0.07	-0.07	-0.11	-0.14	-0.10	-0.20	1

TABLE 5
CORRELATION MATRIX FOR SMALLER FIRMS

	Mean	Std. Deviation	NPV	FALEXP	SCOPE	TYPE	PALEXP	PREP	FSIZE	FAGE	λ	Y94	Y95	Y97	Y98	Y99	Y00	Y01	Y02	Y03
NPV	13,01	86,85	1																	
FALEXP	1.22	0.52	0.47	1																
ASCOPE	0.57	0.04	0.04	0.05	1															
ATYPE	0.41	0.04	0.14	-0.08	0.28	1														
PALEXP	4.40	4.92	0.20	0.30	-0.03	-0.06	1													
PREP	6.93	1.04	0.08	0.06	-0.07	-0.03	0.18	1												
FSIZE	2.04	0.76	0.26	0.39	0.14	0.11	0.26	0.08	1											
FAGE	13.49	11.64	-0.03	0.02	0.02	-0.07	0.17	-0.03	0.20	1										
λ	1.78	0.01	-0.15	-0.10	-0.08	0.19	0.06	-0.28	0.07	-0.04	1									
Y94	0.02	0.01	-0.02	-0.03	-0.01	0.02	-0.09	-0.20	0.01	-0.04	0.40	1								
Y95	0.04	0.01	-0.04	-0.05	-0.10	0.03	0.36	-0.13	0.05	-0.06	0.59	-0.03	1							
Y97	0.06	0.02	0.63	0.18	0.10	0.16	0.09	-0.01	0.21	-0.11	-0.21	-0.03	-0.05	1						
Y98	0.04	0.01	-0.03	-0.03	0.02	0.16	0.05	-0.06	-0.08	0.06	0.00	-0.03	-0.05	-0.05	1					
Y99	0.10	0.02	-0.02	0.14	-0.04	-0.22	0.07	0.05	0.04	0.08	-0.07	-0.05	-0.09	-0.08	-0.08	1				
Y00	0.14	0.03	-0.04	-0.06	-0.04	-0.07	0.24	0.00	0.06	-0.02	-0.15	-0.05	-0.09	-0.08	-0.08	-0.14	1			
Y01	0.10	0.02	-0.03	0.13	-0.02	-0.18	0.00	-0.10	-0.05	0.03	-0.17	-0.05	-0.09	-0.08	-0.08	-0.14	-0.12	1		
Y02	0.23	0.03	-0.09	-0.10	-0.01	-0.07	-0.20	0..24	-0.16	0.00	-0.49	-0.08	-0.15	-0.14	-0.14	-0.24	-0.21	-0.21	1	
Y03	0.12	0.03	-0.05	-0.04	0.07	0.08	0.13	0.16	0.00	0.02	0.16	-0.04	-0.07	-0.06	-0.06	-0.11	-0.11	-0.11	-0.19	1

Hypotheses Tests and Controls

To test the hypotheses, I compared three models for both larger and smaller firms. The results appear in Tables 6, 7, and 8. Model 1 captures the effects of firm characteristics on the financial gains to larger and smaller firms. Model 2 captures the effects of firm characteristics and alliance characteristics on the financial gains to larger and smaller firms. Model 3 captures the effects of firm characteristics, alliance characteristics, and partner characteristics on the financial gains to the larger and smaller firms.[7] Table 6 suggests that the explained variance for larger firms in Model 3 (adjusted $R^2 = 0.47$) is significantly higher than the explained variance in Model 1 (adjusted $R^2 = 0.27$) and that in Model 2 (adjusted $R^2 = 0.29$). Similarly, Table 7 suggests that the explained variance for smaller firms in Model 3 (adjusted $R^2 = 0.28$) is significantly higher than the explained variance in Model 1 (adjusted $R^2 = 0.20$) and that in Model 2 (adjusted $R^2 = 0.24$). Therefore, I focus only on the parameter estimates in Model 3 in discussing the results. Table 8 shows the results of the tests of differences between the corresponding coefficients for the larger and smaller firms.

[7] I compared models for larger and smaller firms by altering the sequence of entry of firm, alliance and partner characteristics into the regression equations. In all these comparison checks, the model with firm, alliance and partner characteristics outperformed all the rival models.

TABLE 6
FINANCIAL VALUE FROM ASYMMETRIC ALLIANCES: SEEMINGLY UNRELATED REGRESSIONS FOR LARGER FIRMS

	Model 1 (N=156)	Model 2 (N=145)	Model 3 (N=102)
Firm alliance experience	0.24 (0.06)***	0.27 (0.05)***	0.15 (0.06)**
Alliance scope		53.71 (22.09) **	40.80 (19.00) **
Alliance type		15.75 (12.54)	24.71 (22.00)
Partner alliance experience			6.21 (2.43)***
Partner innovativeness			0.01 (0.00)**
Control variables			
Firm size	13.64 (18.83)	19.11 (13.17)	- 0.00 (0.00)**
Firm age	0.27 (0.35)	- 0.53 (0.41)	- 0.16 (0.27)
Selection correction (λ)	- 137.03 (51.44)**	- 134.26 (46.14)***	- 166.07 (38.53)***
Firm fixed effects	4 out of 11 fixed effects significant*	4 out of 11 fixed effects significant*	4 out of 11 fixed effects significant*
Chi-square (χ^2)	63.82***	62.40***	116.80***
R^2 (Overall)	0.27	0.29	0.47

* p < 0.10, ** p < 0.05, *** p < 0.01. The dependent measure is the change in the firm's market value measured in millions of dollars. Estimates of year and industry dummies are insignificant, so they are not shown in the table.

TABLE 7
FINANCIAL VALUE FROM ASYMMETRIC ALLIANCES: SEEMINGLY UNRELATED REGRESSIONS FOR SMALLER FIRMS

	Model 1 (N=156)	Model 2 (N=145)	Model 3 (N=102)
Firm alliance experience	2.60 (0.43)***	2.64 (0.73)***	3.15 (0.64)***
Alliance scope		7.85 (5.84)	7.18 (6.13)
Alliance type		25.98 (11.35)**	40.61 (19.24)**
Partner alliance experience			0.07 (0.19)
Partner reputation			- 7.60 (8.72)
Control variables			
Firm size	- 0.00 (0.00)**	- 0.00 (0.56)	- 0.00 (0.45)
Firm age	- 0.01 (0.48)	- 0.00 (0.83)	- 0.37 (0.79)
Selection correction (λ)	- 3.24 (2.66)	- 10.04 (5.98)*	- 42.03 (24.22)*
Firm fixed effects	0 out of 3 fixed effects significant*	0 out of 3 fixed effects significant*	0 out of 3 fixed effects significant*
Chi-square (χ2)	34.38***	37.80***	39.57***
R^2 (Overall)	0.20	0.24	0.28

* p < 0.10, ** p < 0.05, *** p < 0.01. The dependent measure is the change in the firm's market value measured in millions of dollars. Estimates of year and industry dummies are insignificant, so they are not shown in the table.

TABLE 8
TEST OF EQUALITY OF COEFFICIENTS BETWEEN LARGER AND SMALLER FIRMS

Variable	Test Statistic (χ^2, d. f.= 1)
Firm alliance experience	21.53***
Alliance scope	5.22**
Alliance type	0.55
Partner alliance experience	9.70***

* p < .10, ** p < .05, *** p < 0.01. The dependent measure is the change in the firm's market value measured in millions of dollars. A significant chi-square statistic implies that the coefficient for the larger firm is significantly different from that for the smaller firm.

H_1 states that alliance experience will exhibit a positive relationship with financial gains to each partner firm. The results from Table 6 suggest that the parameter estimate of firm alliance experience is positive and significant ($p < 0.05$) for the larger firm. Specifically, every additional alliance by a larger firm adds approximately $0.15 million to the shareholder value of the larger firm. From Table 7, the parameter estimate for the effect of prior alliance experience is also positive and statistically significant ($p < 0.001$) for the smaller firm. However, every additional alliance by a smaller firm contributes approximately $3.15 million to the value of the smaller firm—much higher than that for the larger firm ($p < 0.001$ from Table 7). Thus, H_1 is supported, but importantly, the size of the effect is asymmetric across the larger and smaller firms.

H_2 states that the financial gains to the larger firm will be greater for broad scope NPD alliances than they are for narrow scope NPD alliances. The parameter estimate of alliance scope is positive and statistically significant ($p < 0.05$), supporting H_2. Specifically, a broad scope alliance increases the market value of the larger firm by $40.80 million relative to a narrow scope alliance. This effect is substantially significant when compared to the mean financial gains to the larger firm ($50.72 million). Although I did not have a formal hypothesis for the effect of alliance scope on the financial gains for a smaller firm, the results suggest that the coefficient of alliance scope for smaller firms is statistically insignificant ($p > 0.10$). That is, the difference between the smaller firm's market value changes between broad and narrow scope NPD alliances is indistinguishable from zero. In addition, the results from Table 7 suggests that alliance scope has a positive and significantly higher impact ($p < 0.01$) on the larger firm's gains than it has on the smaller firm's gains.

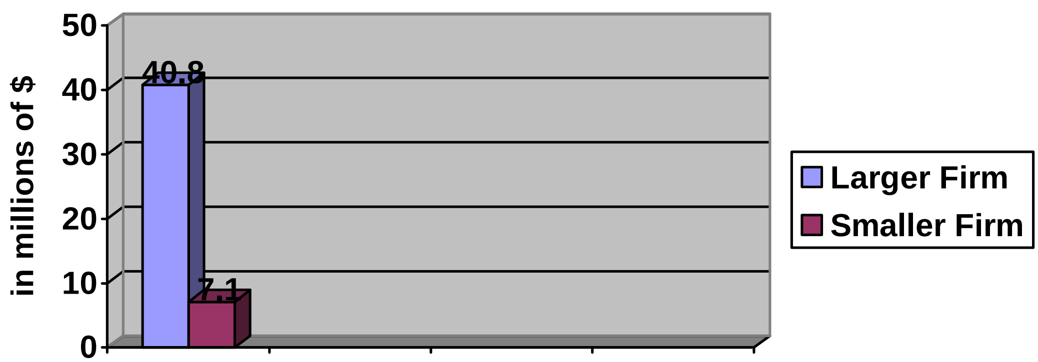
H_{3a} argues that the financial gains to larger firms will be greater for link alliances than they are for scale alliances. Contrary to H_{3a}, I find that the effect of alliance type on change in shareholder value of the larger firm is statistically insignificant ($p > 0.10$). For a link alliance to have a greater impact on change in shareholder value of a larger firm than a scale alliance, it would have to bring a sufficiently high level of complementary competency to NPD. The smaller firms in the data perhaps did not bring such high complementary value to the larger firms.

H_{3b} argues that the financial gains to smaller firms will be greater for scale alliances than they are for link alliances. The results suggest that the parameter estimate of alliance type is positive and statistically significant ($p < 0.05$), supporting H_{3b}. Specifically, a scale alliance contributes $40.61 million more to the value of the smaller firm than does a link alliance. This contribution is considerably large when compared to the mean increase in shareholder value of $13.01 million for the smaller firm. However, the results from Table 8 suggest that the parameter estimate of alliance type for the smaller firm is not significantly different from that for the larger firm ($p > 0.10$). In addition, I tested for possible interaction effects of alliance type and alliance scope on the financial gains. The interaction effect turned out to be statistically insignificant ($p > 0.10$), so I did not include it in the final model. To sum up the effects of alliance characteristics, I find considerable asymmetries between larger and smaller firms with regard to the impact of alliance scope, but not so with regard to alliance type.

With regard to Hypothesis 4a about the relationship between partner alliance experience and financial gains to the larger firm, the parameter estimate of partner alliance experience is positive and significant at the 0.01 level. In terms of magnitude, every additional past alliance of the smaller partner firm increases the financial gains to the larger firm by approximately $6.21 million. Thus, H_{4a} is strongly supported. However, the effect of partner alliance experience on the financial gains for smaller firms is statistically insignificant ($p > 0.10$). Thus, H_{4b} is not supported. Consistent with H_{4a} and H_{4b} results, the parameter estimates from Table 7 suggest that partner alliance experience has a positive and significantly higher ($p < 0.01$) impact on the larger firm's gains than it has on the smaller firm's gains.

H_5 argues that the financial gains to smaller firms are greater when partnering with larger firms of high reputation than they are when teaming up with larger firms of low reputation. However, the results suggest that the effect of partner reputation on the financial gains of smaller firms is not statistically significant ($p > 0.10$). Hence, H_5 is not supported.[8] According to H_6, the financial gains to larger firms will be greater when partnering with innovative smaller firms than when partnering with non-innovative smaller firms. The effect of partner innovativeness is significant ($p < 0.05$), supporting H_6. Figures 2, 3, 4 & 5 depict the asymmetric gains to larger and smaller firms from NPD alliances.

FIGURE 2
FINANCIAL RETURNS FROM BROAD SCOPE NPD ALLIANCES



[8] The reputation ratings for larger firms were available in the *Fortune* database only for 130 firms. Therefore, we do not rule out the possibility that the inability to detect the positive effects of reputation on smaller firm value may be due to lack of statistical power. In addition, we recognize that the use of a global measure of reputation could have lead to statistical insignificance (Fryxell and Wang 1994).

FIGURE 3
FINANCIAL RETURNS FROM SCALE NPD ALLIANCES

FIGURE 4
FINANCIAL RETURNS FROM FIRM ALLIANCE EXPERIENCE

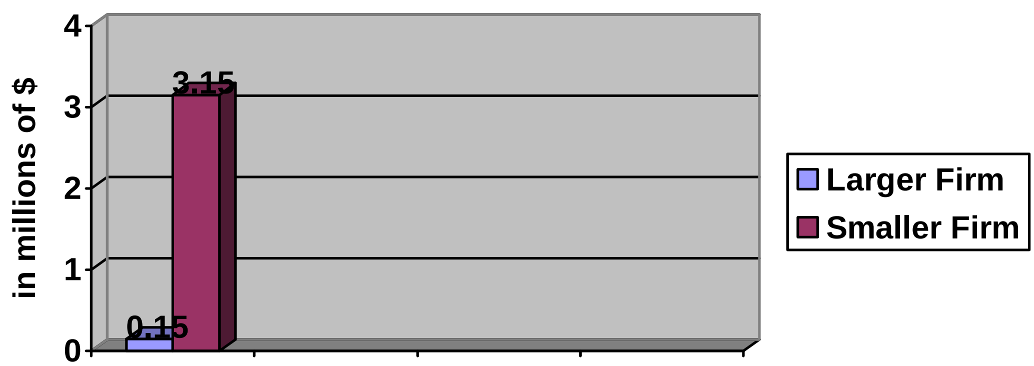


FIGURE 5
FINANCIAL RETURNS FROM PARTNER ALLIANCE EXPERIENCE

The effects of the control variables are either in the expected directions or are insignificant. Firm size is negatively associated with the gains of the larger firm ($p < 0.05$), but is not significantly related to the gains of the smaller firm ($p > 0.10$). Firm age is not statistically significant for both larger and smaller firms ($p > 0.10$). Selection correction is negative and significant for both larger and smaller firms ($p < 0.10$), underscoring the need to control for selection bias. None of the year or industry dummies, however, is significant ($p > 0.10$). Finally, four of the 11 firm fixed effects are significant in the larger firm equation ($p < 0.10$), but none are significant in the smaller firm equation ($p > 0.10$). Thus, controlling for unobserved firm heterogeneity is important for larger firms, but not for smaller firms.

I performed several analyses to ensure the robustness of the findings. A summary of these analyses and their results is reported in Appendix 2. Details on an analysis of long-term returns to NPD alliance performed as a robustness check appears in Appendix 3. Overall, these additional analyses checks reveal that the analyses and results are robust.

A summary of the results appears in Table 9. Firm alliance experience has a positive and significant effect on the financial gains of both larger and smaller firms. However, the similarity between larger and smaller firms ends there. The effects of alliance scope, alliance type, and other partner characteristics on financial gains are asymmetric across larger and smaller firms. Larger firms gain more from broad-scope alliances, but smaller firms' gains are not related to alliance scope. In contrast, smaller firms gain from scale alliances, but larger firms' gains are not related to alliance type. Partner alliance experience has a positive influence on the gains of the larger firm, whereas it is not related to the gains of the smaller firm. Furthermore, partner innovativeness has a positive influence on the gains of the larger firm, but partner reputation has no effect on the gains of the smaller firm. Finally, although firm alliance experience has a positive effect on the financial gains of both larger and smaller firms, the absolute value of gains is much higher for the smaller firms than it is for the larger firms.

TABLE 9
SUMMARY OF RESULTS: STUDY ONE

Factors (Hypotheses)	Predicted Effects Larger Firm	Predicted Effects Smaller Firm	Results Larger Firm	Results Smaller Firm	Results Relative Coefficients	Brief Rationale
Firm alliance experience (H_1)	+	+	+	+	$\beta_1 < \gamma_1$	Although prior alliance experience adds value to both larger and smaller firms, every additional NPD alliance is more beneficial to the smaller firm as it provides more critical information to investors regarding the smaller firm's future revenues.
Alliance scope (H_2)	+	N. P	+	N. S	$\beta_2 > \gamma_2$	Larger firms tend to gain disproportionately from broad-scope NPD alliances because of the greater opportunity for private gains.
Alliance type (Scale versus link) (H_{3a} & H_{3b})	-	+	N. S	+	$\beta_3 = \gamma_3$	Greater contribution of resources by the smaller firm to downstream activities of NPD shifts the balance to the middle resulting in both the larger and smaller firms gaining equally from scale alliances.
Partner alliance experience (H_{4a} & H_{4b})	+	+	+	N. S	$\beta_4 > \gamma_4$	Partner alliance experience matters more for the larger firm because unlike for the smaller firm, it helps screen partner firms with unproven track records (typically smaller firms).
Partner innovativeness (H_5)	+	N. P	+	N. A	N. A	Partner innovativeness matters from the standpoint of the larger firm as it provides new information to investors about the quality of NPD effort pursued by the larger, well-established firm.
Partner reputation (H_6)	N. P	+	N. A	+	N. A	It may be unrealistic to expect a transfer of reputation from the larger firm to the smaller firm without accounting for the tangible resources contributed by the larger firm to the NPD alliance.

Notes: N. S – Not significant, N. A - Not applicable, N. P – No prediction

THEORETICAL AND MANAGERIAL IMPLICATIONS

The first main finding from this study is that an asymmetric NPD alliance is not a win-lose partnership, but a win-win or shareholder value-adding alliance for both the larger and smaller partner firms. Although previous studies have not examined shareholder value changes to NPD alliances, they have suggested that the value of one partner firm may improve at the expense of the other partner. The findings also show that the magnitudes and drivers of the financial gains are different across the larger and smaller firms.

Prior research provides only partial insights into the effects of firm characteristics, alliance characteristics and partner characteristics on firm value, albeit not in the NPD context. This study extends prior research by studying all the effects in a single framework and by empirically showing that the relative influences of these characteristics on the firm values of smaller and larger firms vary substantially. While prior research seems to suggest that alliance characteristics matter equally to the partner firms in an alliance, the motivation for firms to enter into asymmetric alliances are different for larger and smaller firms. Broad scope alliances are intrinsically complex and uncertain, pose greater threats of opportunism, and result in frequent ex-post alliance changes (Oxley and Sampson 2004; Reuer, Zollo, and Singh 2002). The results suggest that broad scope NPD alliances create greater financial value for larger firms than do narrow scope NPD alliances. However, the effect for smaller firms is not significantly different between broad scope alliances and narrow scope alliances. Likewise, I find that smaller firms tend to gain more from scale alliances than they do from link alliances.

The finding regarding the smaller firm is new and the result relating to the larger firm is consistent with prior research. This shows that as long as the alliance profits are high, there is an incentive for the larger firm to enter into the alliance, whereas the incentive for the smaller firm to enter into the alliance depends on how the benefits from technology development would be shared (Lerner and Merges 1998; Veugelers and Kesteloot 1996).

These findings have several useful implications for managerial practice. For the larger firm to gain from its partnership with the smaller firm, the alliance agreement needs to be broad-based involving cooperation in more than one functional area. In contrast, for the smaller firm to gain from its partnership with the larger firm, greater pooling of resources through a scale alliance is desirable as it increases the opportunity for symmetric revenue sharing and lowers the possibility of exploitation by the larger partner.

Prior research also suggests that alliance experience of the firm creates value because of learning effects (Anand and Khanna 2000; Sampson 2005). Consistent with these research findings, I also find that alliance experience contributes to the financial value of both larger and smaller firms. However, I find that the magnitude of the gains differs considerably across larger and smaller firms. I find that every additional alliance creates more financial value for smaller firms than it does for larger firms. A smaller change in the value of the larger firm due to firm alliance experience is consistent with the fact that the stock market is well informed about the strategies of larger firms and an additional past alliance by the larger firm may be insufficient to result in a large change in the firm's value. In contrast, the stock market has considerably less information about the strategies of smaller firms and hence, every additional alliance with a larger firm aids the investor in resolving the uncertainty related to its future cash flows. The implication for a manager of a smaller firm is that every additional past alliance with other firms not only improves its chances of survival, but also signals the firm's financial potential to investors. Alliances with larger, well-established firms are indeed the path to growth for smaller, entrepreneurial firms. Managers in larger firms need to note that every additional past alliance is valued lower than that for a smaller firm as it does not provide a significantly new piece of information to investors. Perhaps, larger firms tend to gain more from their ability to manage a portfolio of alliances (Wuyts, Dutta, and Stremersch 2004) than they do from incremental alliances with smaller firms. Indeed, large firms such as Hewlett-Packard and Eli Lilly have mastered alliances by establishing exhaustive knowledge stores that aid in partner selection as well as alliance design (Johnson, Sohi, and Grewal 2004; Kale, Dyer, and Singh 2002).

A rich body of literature suggests that endorsement by a larger, powerful firm enables smaller firms to overcome their liability of smallness that stems from their lack of reputation (Baum, Calabrese, and Silverman 2000; Gulati and Higgins 2003; Stuart 2000). Interestingly, I find that neither partner alliance experience nor partner reputation has a significant impact on the financial gains to the smaller firm in the sample. However, the lack of empirical support for H_{4b} and H_5 suggests that larger firms partnering with inexperienced or less innovative smaller firms tend to be viewed as less valuable. An implication is that asymmetric NPD alliances are characterized by asymmetric information. Specifically, the characteristics of the smaller partner play a crucial role in reducing the adverse selection problem faced by the larger firm when selecting a smaller alliance partner. However, I find that the larger partner's attributes do not matter from the standpoint of the smaller firm's market value. These findings imply that in selecting smaller firms with whom to partner, larger firms need to pay closer attention to their partner's attributes (e.g., partner alliance experience and partner innovativeness) because of their ability to reduce investor uncertainty about the quality of smaller firms.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

Like most empirical research, this study suffers from certain limitations that can be addressed by future research. The first limitation is the absence of granular information pertaining to alliance agreements (e.g., terms and conditions, deal value and resource contributions by the larger and smaller partners). Future research could collect and use such information. Second, the sample for this study is limited to publicly traded U.S. firms in the information technology and telecommunication industries. Future research needs to examine whether the findings generalize to other industries characterized by asymmetric NPD alliances (e.g., biotechnology and pharmaceutical industries). Third, although stock prices provide good estimates of future performance, they can be limiting in some respects. For example, the underlying assumption that stockholders are the only stakeholders is somewhat restrictive. Future research could incorporate comprehensive performance measures by including the views of multiple stakeholders as well as by taking into account the actual cash flows realized by firms.

CHAPTER III

DETERMINANTS OF NEW PRODUCT ALLIANCE TERMINATIONS

OVERVIEW

Managing multiple new product partnerships is a complex endeavor requiring incumbents to make numerous decisions periodically. One such decision pertains to pulling the plug on 'less promising' NPAs and diverting resources to other NPAs in the portfolio. Against this backdrop, a number of research questions merit investigation. What are the determinants of NPA terminations? How does market focus and technology focus of the incumbent's NPA portfolio impact NPA terminations? Are NPA terminations influenced by the age of the incumbent's product portfolio? Does competition in product markets increase or decrease the hazard of termination? Are NPA terminations impacted by its partner's financial conditions?

The hypotheses are tested on a unique database comprised of 401 new product alliances involving 24 pharmaceutical firms during 1990-2005. NPA terminations are modeled using Cox's proportional hazard specification that accounts for the unobserved heterogeneity of firms with multiple NPAs (through gamma distributed frailty effects), competing risks and ties among NPA duration times (using Efron approximation). The results suggest that NPA terminations are not made in isolation but are influenced by composition of the firm's portfolio. The results relating to *firm portfolio characteristics* suggest that while firms with greater product category focus have lower hazard of termination, firms with greater technology focus have higher hazard of termination. In addition, the hazard of termination is lower for firms with aging portfolios. The results related to *product-market factors* suggest that highly competitive product-markets, firms tend to continue with the existing NPA rather than terminating it. The results relating to *partner-specific factors* are more complex. Partner value has a U-shaped impact on the hazard of NPA termination. The hazard of termination is lowest at moderate levels of partner value. The implications of the findings for future research and management practice are outlined.

INTRODUCTION

It is well-known that incumbent firms in high technology industries (e.g., pharmaceuticals, semiconductors, information technology) typically pursue multiple new product alliances with entrepreneurial firms to bolster their product pipelines. Managing multiple new product partnerships is a complex endeavor requiring incumbents to make numerous decisions periodically. One such decision pertains to pulling the plug on 'less promising' NPAs and diverting resources to other NPAs in the portfolio (Bordley 2003; Hauser, Tellis, and Griffin 2006). Marion Merell Dow, a pharmaceutical firm, entered into a 10-year agreement with Alteon in 1990 to develop and market *Pimagedine* and selected compounds. The scope of the 10-year agreement included a R&D collaboration, $20M funding for Pimagedine's clinical development and provisions for the joint promotion and sale of the product in the U.S., Canada and Western Europe. However, Marion Merrell Dow ended its alliance with Alteon much before the completion of the ten year period. According to managers in Alteon, any termination other than an unanticipated failure of the product development program was never envisioned by the alliance partners (Van Brunt 1999).

NPAs can be terminated for a number of reasons such as when partners have accomplished the objectives or when the NPA technology has failed. Yet, casual observation suggests that incumbents manage and balance their portfolio by weeding out NPAs that do not fit its strategic objectives (Chan, Nickerson, and Owan 2007). NPA terminations are important from an incumbent's perspective for atleast two reasons. First, NPA terminations impact how incumbents allocate resources to its existing and new R&D partnerships and can lower a firm's NPD costs by as much as 65% (Cooper, Edgett, and Kleinschmidt 2001). This is significant because new product development costs continue to escalate in a number of industries. Industry reports suggest that the cost of developing new drugs has increased to $800 million in 2000 (Dimasi 2000). Second, large firms that are strategic in terms of which R&D alliances to terminate tend to have higher R&D output and lower R&D output volatility compared to firms that do not consider the relationship of the NPA to the overall portfolio (Cockburn and Henderson 1996; Kavadias and Chao 2006).

NPA portfolio management is defined as a 'dynamic decision process in which a business' list of active new product partnerships is constantly revised and updated' (Cooper, Edgett, and Kleinschmidt 1998). NPA portfolio management issues such as go/kill investment decisions are encountered by firms in a number of industries such as information technology, telecommunications and pharmaceuticals. In high technology markets, the breadth of product-markets targeted and the number of technologies employed represent important strategic choices for incumbents that impacts its innovation output and profitability (Grewal, Ding, and Liechty 2006; Wuyts, Dutta, and Stremersch 2004; Cooper, Edgett and Kleinschmidt 1998). However, incumbents are constrained in the choices of product-markets and technologies they pursue by the state of its existing product pipeline. For instance, reports in the pharmaceutical industry suggest that Merck's threshold for continuing/abandoning new product partnerships has changed significantly between 1980 and 2003. Buoyed by a strong portfolio and relatively less competition in 1980, Merck pursued an aggressive strategy of pursuing high risk-high return NPAs. However, with fewer successful candidates emerging from its alliance and product portfolio, by 2003 Merck shifted its focus to pursuing low risk-low return NPAs (Bellucci 2005). Such shifts in preferences are not unique to a firm or an industry. Generally, any firm that is likely to experience a decline in revenues because of expiration of the commercialized products faces similar pressures. Recent models by Grossman, Hart and Moore (reviewed in Hart 1995) suggest that structure of technology alliances is predicted by the difficulty faced by young-technology firms in raising capital from public and private investors because of information asymmetries surrounding its projects. Furthermore, the wide fluctuations in the availability of capital from public and private investors render writing complete contracts almost impossible in such industries.

The research questions I seek to address are as follows. What are the determinants of NPA terminations? How does product category focus and technology focus of the incumbent's NPA portfolio impact NPA terminations? Are NPA terminations influenced by the age of the incumbent's product portfolio? Does competition in product markets increase or decrease the hazard of termination? Are NPA terminations impacted by changes in the partner's financial conditions?

This study seeks to make the following contributions to the literature on NPAs. First, this is one of the early studies to examine how NPA termination decisions of incumbents are influenced by the firm's portfolio (i.e., NPA and product) characteristics. While prior research acknowledges that firms need to manage their NPA portfolios as a strategic goal (Wind and Mahajan 1997; Cooper, Edgett, and Kleinschmidt 1998), empirical research linking portfolio characteristics to NPA terminations is virtually absent. By investigating interdependencies in the portfolio, this study sheds insights into which NPAs in a firm's portfolio have higher and lower hazards of termination. Second, I empirically investigate the role of competition on new product alliance terminations. Specifically, I examine two distinct sources of competition that are likely to impact NPA terminations: intra-alliance (i.e., partner value) and inter-alliance competition (i.e., product market rivalry). While prior research has examined either intra-alliance rivalry (Kogut 1991) or inter-alliance rivalry (Pisano 1990), this is the first study to examine both competitive effects in the same framework.

CONCEPTUAL FRAMEWORK AND RESEARCH HYPOTHESES

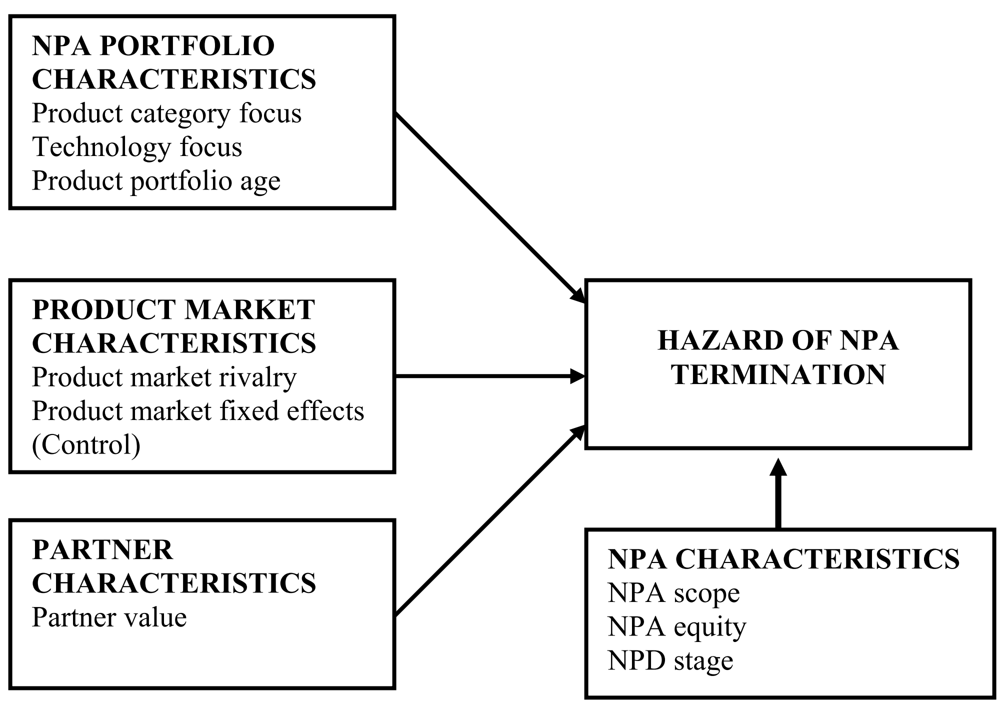
The issue of NPA terminations is related directly and indirectly to a number of literature streams. First, the product management literature in marketing has for long advocated a stage-gate approach for assessing whether projects are to be advanced or discontinued.

In this approach, gates represent the nodes where cross-functional teams make go/no-go decisions based on economic analysis (e.g., NPV) based on criteria such as market attractiveness, technical feasibility, new product advantage etc (Wind and Mahajan 1997; Cooper, Edgett, and Kleinschmidt 1998; Griffin 1997). There is also a stream of research suggesting that NPD continuation and termination decisions are attributable to managerial biases (Boulding, Morgan, and Staelin 1997; Schmidt and Calantone 2002). However, the focus of these research streams is on new products developed internally and not on new products developed through partnerships and collaborations.

Second, there is a large body of literature that views investment or divestment choices of firms as real options. Investments in new product alliances in high technology settings resemble real options since such environments are characterized by uncertainty, long time horizons and asymmetric pay-off distributions (Dixit and Pindyck 1994; McGrath and Nerkar 2004). Prior research has considered investment in an R&D alliance to be an isolated option and the overall value of a portfolio of options as linearly additive (i.e., sum of the values of individual options). This is limiting because product-markets are characterized by interdependencies and therefore, a portfolio approach that allows for the possibility of correlated options is more realistic (i.e., R&D alliances) (Wuyts, Dutta, and Stremersch 2004; Devinney and Stewart 1988; Vassolo, Anand and Folta 2004).

Building on prior research in new product development and real options, I argue that new product alliance terminations are attributable to 1) the firm's portfolio characteristics (i.e., product category focus [Cockburn and Henderson 1996; Grewal, Ding, and Liechty 2006], technology focus [Wuyts, Dutta, and Stremersch 2004; Powell, Koput, and Smith-Doerr 1996], product portfolio maturity [Higgins and Rodriguez 2006; Chan, Nickerson, and Owan 2007]), 2) product-market characteristics (i.e., product market rivalry [Pisano 1990; Folta and Miller 2002]) and 3) partner characteristics (i.e., partner value [Folta and Miller 2002]). Figure 6 depicts the conceptual model of the determinants of NPA terminations.

FIGURE 6
DETERMINANTS OF NPA TERMINATIONS: A CONCEPTUAL MODEL



Firm Portfolio Characteristics

Product category focus. Product category focus refers to the firm's allocation of effort to product categories. Firms vary considerably in their breadth product markets they seek to pursue. The rationale for firms to target multiple product markets is to diversify the risk associated with product-markets. At the same time, other firms focus on fewer product markets in an effort to develop category-specific experience. For example, Wyeth has been noted for its focused product pipeline (e.g., neuroscience) whereas Pfizer's pipeline is known for the breadth of product markets targeted. Although projects in the same category might imply higher risk (DiMasi 2000), complementarities exist within the sub-categories, which are determined by the diseases or the conditions that the drugs are used to treat. This is primarily because knowledge gained through research in one project area may be of direct relevance to other projects within the same category. Therefore, while a firm may seek to pursue new products for specific applications within a product category, uncertainty and serendipity in the early stages of the NPD process often results in uncovering promising candidates for other areas in the same category. For instance, within the hematologics category, the indications of drugs in Estrogens/Progestins and contraceptives overlap considerably (Acemoglu and Linn 2004). However, the benefits of scope may not materialize in diverse product categories where the knowledge to be transmitted is sticky (Cockburn and Henderson 1996). Given the existence of such ex-ante uncertainties, investments made in a particular product category are deployable more within the same product category than across diverse product categories. More generally, partial use of investments across R&D alliances has been shown to lead to super-additive outcomes for the portfolio of options (Vassolo, Anand, and Folta 2004). Building on these arguments, I expect NPAs in product markets that overlap considerably with the firm's NPA portfolio will have a lower likelihood of termination. Therefore:

> H_7: The hazard of NPA termination will be lower for alliances in product categories characterized by a greater overlap with the firm's NPA portfolio.

Technology focus. A firm's *technology focus* refers to the degree to which a firm employs similar or related sets of technologies to pursue innovation. In the context of internal R&D, incumbent firms face inertial pressures and are susceptible to the 'core rigidity trap' that stems from the use of similar technologies (Leonard-Barton 1992). For example in the optical industry, incumbents face the challenge of overcoming current storage limits of today's DVD standard by using laser pickup technology that utilize inert gases (Rosenkopf and Nerkar 2001). However, discovery of new products often requires exploring diverse and novel technological paths. One of the reasons incumbent firms enter into new product alliances is because it provides access to multiple technologies and enables them to overcome the constraints of localized search. Although developing technologically diverse NPA portfolios is beneficial for successful innovation, pursuing multiple distinct technological domains requires higher investments and lowers profitability (Wuyts, Dutta, and Stremersch 2004). According to the real options framework, if a firm has a set of NPAs employing the same technologies, the overall net present value of the portfolio of NPAs is lower because of the opportunity to switch (Vassolo, Anand, and Folta 2004). Therefore, I expect that NPAs with technologies that overlap considerably with the firm's NPA portfolio would have a higher likelihood of being terminated.

H_8: The hazard of NPA termination is lower for alliances based on technologies characterized by a greater overlap with the firm's NPA portfolio.

Product portfolio age. A firm's *product portfolio age* refers to the maturity of the firm's product pipeline. A firm's product portfolio age is dynamic because a number of candidates in the firm's NPA portfolio might ultimately reach the market. Published reports in the business press suggest that the maturity of the product pipeline impacts the strategic behavior of incumbents in high technology markets. For example, a Wall Street Journal article states:

> "And in a radical change, some companies are shedding their Hollywood-style focus on finding a few big hits -- a longtime practice that left them vulnerable when patents expired -- in favor of developing a broader range of drugs. Ultimately, that change could yield drugs aimed at smaller markets, and for rarer illnesses, which might have been shelved in the past." (Tanouye and Langreth 1997).

Recently, empirical evidence has been offered to suggest that thinning product pipelines or deteriorating R&D productivity forces incumbents to acquire research intensive partners with promising product candidates (Higgins and Rodriguez 2006). Likewise, insights from the product management literature suggests that firms with maturing product portfolios lower the threshold for advancing R&D projects (Chan, Nickerson, and Owan 2007; Gino and Pisano 2006). Although large firms with multiple candidates in development would suggest a lower likelihood of advancing NPAs forward, a firm with a mature product portfolio is likely to experience a decline in its revenues because of generic competition. In such situations, we expect that firms would be 'less tough' on terminating NPAs. The reason firms lower their NPA termination criteria in the face of an aging product portfolio is to avoid incurring adjustment costs of co-specialized investments such as those on distribution and sales force (Chan, Nickerson, and Owan 2007). Based on these arguments, I advance the following hypothesis:

> H_9: The hazard of NPA termination will be lower for alliances of firms with aging product portfolios.

Product-Market Characteristics

Product market rivalry. Product-market rivalry refers to the extent of competition a firm faces in a given product-market. It has been recently argued that in fiercely contested product markets, firms are unlikely to buy out partners because preemption by rivals might reduce the value of the underlying growth option (Folta and Miller 2002). However, product-markets are fiercely contested because the target market is potentially attractive in terms of future revenues (McGrath and Nerkar 2004). In such markets, a firm's decision to terminate NPAs is influenced by whether it can find a new partner in the same product-market. Increased product-market rivalry implies that the incumbent's ability to pursue more NPAs in the product market is reduced considerably because most of the entrepreneurial firms are already engaged in NPAs in the same product-market with well-established firms. Large firms tend to avoid entering into NPAs with smaller firms who have active NPAs in the same product-markets with other large firms for atleast two reasons (Pisano 1990). First, the know-how generated from a R&D project may be closely linked with what is created in other R&D projects. Therefore, incumbents face the hazard of the new entrant selling the know-how from the project to its rivals in the product-market (Pisano 1990). Secondly, even if there is no diversion of efforts by the entrant to other projects, incumbents will find it extremely difficult to attach claims to much of the intellectual property from the specific new product alliance. Based on these arguments, I expect incumbents in fiercely contested product markets will be less likely to abandon NPAs.

> H_{10}: The hazard of NPA termination will be lower for alliances in product markets characterized by high levels of rivalry.

Partner Characteristics

Partner value. Partner value refers to the financial value accorded to the partner by external entities such as venture capital companies and financial markets. Changes in the new entrant's financial position are likely to impact the hazard of termination because of two different reasons. On the one hand, although the NPA between the firms may have existed for some time, there is still uncertainty regarding the viability and quality of the NPD program of the smaller partner. In this situation, finances raised by the smaller partner from external sources serves as an endorsement of its NPD capability. On the other hand, the R&D literature suggests that high levels of external funding received by the smaller partner (i.e., research unit) often results in the majority of control rights getting assigned to the smaller firm (Aghion and Tirole 1994; Lerner and Merges 1998). For example, Immulogic, a new entrant in the biopharmaceutical industry faced a choice of entering into an alliance or raising equity through an initial public offering. A factor that influenced Immulogic's decision to raise equity from the public market was the fear that the pharmaceutical partner might press for concessions on key governance and financial issues. Consequently, Immulogic deferred negotiating an alliance until it went public in May 1991 (Lerner 1992). Such evidence suggests that the allocation of control rights from a NPA is closely linked to the smaller firm's financial conditions. Therefore, improvements in the partner's financial position often results in protracted re-negotiations requiring the focal firm to cede important control rights relating to the NPD. Incumbents in such situations would be inclined to terminate the NPA because of lower residual claims from the innovation effort. Combining these two theoretical predictions, I expect a U-shaped relationship between partner valuation and termination. Therefore:

> H_{11}: The hazard of NPA termination will exhibit a U-shaped relationship with changes in the valuation of the smaller alliance partner. It will be lowest for moderate levels of valuation of the smaller alliance partner.

DATA

The empirical setting for testing the research hypotheses is the pharmaceutical industry. The data to test the hypotheses was collected from multiple data sources. The data for new product alliances between pharmaceutical firms and biotechnology firms were collected from the *Recap* database.[9] Although, the *Recap* database tracks R&D alliances of pharmaceutical firms from 1988, fine-grained information on R&D agreements are available only from 1990. Consequently, the starting date for the sample was 1990. The database was searched for agreements that involved collaboration, research and

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[9] Recap is a consulting firm based in San Francisco, California that specializes in tracking R&D alliances, licensing arrangements, product sales and capitalization information in the biotechnology industry. The data in this database has been collected by examining SEC and state filings, news reports, industry reports, press releases and scientific meetings.

development and co-development between pharmaceutical and biotechnology firms. Licensing agreements, partnerships involving biotech-biotech, biotech-university and pharmaceuticals-university were excluded from the sample because these arrangements do not have commercialization objectives. In addition, this database also tracks the deal size, therapeutic category targeted, technologies employed, the development stage of the product at the time of signing and the amount of equity purchased. This information is utilized to construct measures of product category focus, technological focus, NPD stage and NPA equity respectively. The dates on new product alliance terminations were retrieved from Recap's alliances database, which tracks the progress of early stage NPAs and clinical trials database, which tracks the progress of late stage NPAs. However, in a few instances, the termination dates were not available in the Recap database. In such situations, the archives of Lexis-Nexis and biotechnology firm's 10k statements were searched to retrieve the date of NPA termination. Table 10 provides a summary of selected NPA terminations included in the sample.

TABLE 10
SUMMARY OF NEW PRODUCT ALLIANCE TERMINATIONS

Pharmaceutical Firm	Target Therapeutic Category	Biotechnology Firm	Termination Summary
Pfizer Inc	Cancer	Megabios Corp.	Megabios Corp. announced today that Pfizer has made the decision to discontinue their research program focused on the development of products for oncology that inhibit new blood vessel formation (angiogenesis).
Janssen (Johnson & Johnson)	Cancer	NeoRX	NeoRx Corp. announced that Janssen Pharmaceutica N.V. will terminate its Avicidin(R) agreement with NeoRx. Janssen is currently completing Phase II trials in patients with advanced colon and prostate cancers.
Johnson & Johnson	Blood & Hematopoietic	Alkermes	Alkermes, Inc announced that the R.W. Johnson Pharmaceutical Research Institute (PRI), a Johnson & Johnson company, has terminated further development of an injectable sustained release formulation of erythropoietin based on Alkermes' ProLease® drug delivery technology.
Schering-Plough	Central Nervous System	Cephalon	Cephalon, Inc announced today that Schering-Plough Corporation will discontinue its funding of the companies' research collaboration to develop compounds for the treatment of Alzheimer's disease.

Data on the pharmaceutical firm's product portfolio age was collected from the list of approved drugs by Inteleos and Food & Drug Administration.[10] These two data sources collectively provided approval dates of all of the drugs for the pharmaceutical firms in the sample. Another unique feature of the Recap database is the biotechnology valuation database that tracks the round-by-round venture capital and equity financing received by biotechnology firms at various points in time. This information was used to construct partner valuation measures. The data collection methodology resulted in a total of 112 terminations out of 401 NPAs involving 24 publicly traded pharmaceutical firms and 241 biotechnology firms between 1990 and 2005. Since the 112 terminations correspond to the 401 NPAs formed between 1990 and 2005, the data is not left-censored. Tables 11 and 12 highlight the frequency distribution of NPA terminations by year and firm respectively. The frequency of terminations appears to steadily increase from 1997 to 2004. In addition, there appears to be considerable differences in the percentage of NPAs terminated by firms. While GlaxoSmithKline, Pfizer and Elan appear to have a greater tendency to terminate NPAs, firms such as Wyeth, Bristol-Myers Squibb and Aventis appear to have a tendency to procrastinate the termination decision.

[10] Inteleos is a database maintained by Elsevier that tracks over 8000 drugs and 1200 pharmaceutical and biotechnology companies

TABLE 11
FREQUENCY DISTRIBUTION OF NPA TERMINATIONS BY YEAR

Year	Number of NPA Terminations
1993	1
1994	3
1995	2
1996	2
1997	13
1998	14
1999	9
2000	5
2001	12
2002	19
2003	15
2004	10
2005	6
2006	1

TABLE 12
FREQUENCY DISTRIBUTION OF NPA TERMINATIONS BY FIRM

Firm	Number of NPAs	Number of NPA Terminations
Mallinckrodt	4	0
Wyeth	21	4
Bayer	7	2
Pharmacia	15	6
Bristol-Myers Squibb	20	4
Abbott	16	5
Pfizer	41	18
Johnson & Johnson	24	7
Merck	27	3
Warner-Lambert	8	0
Schering	36	10
Baxter	7	2
Elan	18	8
Rhone-Poulenc Rorer	4	1
Kirin-Amgen	5	0
Eli Lilly	27	9
Novo Nordisk	6	2
GlaxoSmithkline	36	15
Organon	5	0
Allergan	8	2
Aventis	26	4
Astra	10	2
Hoechst Marion Roussel	5	4
Novartis	24	4

MEASURES AND METHODOLOGY

Table 13 provides an overview of the measures and their operationalizations.

TABLE 13
VARIABLE OPERATIONALIZATION AND DATA SOURCES: STUDY TWO

Variable	Operational Measure	Data Source(s)
NPA termination	1= Terminated 0= Right censored	Recap Alliance Database, Recap Clinical Trials Database, Lexis Nexis
Product category focus	Ratio of the investments in a product market to investments in all product markets	Recap Alliance Database
Product portfolio age	Average age of the firm's products in the market at the time of the termination	Inteleos, FDA
Product market rivalry	Number of new product alliances entered by other firms in the therapeutic category between NPA formation and termination	Recap Alliance Database
Partner value	Finances received by the biotechnology firm ($M) between NPA formation and termination from external investors	Recap valuation database
Partner alliances	Number of NPAs of the biotechnology firm until NPA formation	Recap Alliance database
NPD Scope	Size of the deal in $M	Recap
NPD Stage	Ordinal measure	Recap
Category fixed effects	Dummy variable	Recap

Dependent Variable

The dependent variable in this study is the hazard of NPA termination. As noted before, NPAs can be terminated for a variety of reasons such as when one of the partners pulls out of the venture or when both parties mutually agree to end the NPA. We classify NPA terminations in which the incumbent stops further investments as 'unilateral terminations' and NPA terminations which end because of successful achievement of objectives or product failures (i.e., poor end-points) as 'mutually agreed terminations'. This approach of classifying terminations is in line with previous research (Reuer and Zollo 2006). Such a competing risks framework allows one to isolate the phenomenon of interest (i.e., incumbent initiated terminations) and test whether different types of NPA terminations are governed by different stochastic processes.

Independent Variables

Product category focus is a ratio measure of the firm's focus on the focal therapeutic category to all other therapeutic categories at the time of the NPA termination. Rather than using a ratio of the count of NPAs in the focal category to the total count of NPAs in all therapeutic categories, this measure was weighted by the investments made in each category. This is important because although a firm may have a large number of alliances in a given category, if the investments are small, the count ratio may not be an appropriate indicator of the firm's category focus.[11] For instance, Wyeth investing $6m in respiratory disorders (i.e., one R&D agreement), $400m in central nervous system

[11] The therapeutic categories used by Recap is in line with the classification by FDA and is similar to the categorization employed in prior research (see Pisano 1990)

(i.e., six R&D agreements), $110m in cardiovascular (i.e., two R&D agreements) and over $500m in infection (i.e., four R&D agreements) is indicative of different research priorities. Therefore, product category focus measure was constructed as the ratio of the investments made in the focal therapeutic category l by firm j up to time t to the total investments made in all therapeutic categories by firm j up to time t. Product category focus is given by:

$$PRODCATFOCUS_{jt} = \frac{I_{jt,l}}{\sum_{l=1}^{L} I_{jt}}$$

Technological focus. The operationalization of technological focus builds on prior research (see Powell, Koput, and Smith-Doerr 1996; Wuyts, Dutta, and Stremersch 2004) and is analogous to the Herfindahl index used for industry concentration. The technological focus of the incumbent j at the time of termination t is given by

$TECHFOCUS_{jt} = \sum_{m=1}^{M} P_{jt}^{\ 2}$ where $P_{jt,m} = \frac{s_{jt,m}}{\sum_{m} s_{jt,m}}$ represents the ratio of the occurrence of a technology m in a firm j’s NPA portfolio to the occurrence of all technologies in firm j’s portfolio.

This measure is scaled between 0 and 1, with 0 representing low technological focus and 1 representing high technological focus. For example, a firm with a portfolio of four R&D agreements comprised of technologies such as monoclonals, peptides, rational drug design and oligonucleotides respectively has a technology focus of 0.25 whereas a firm with a portfolio of four R&D agreements comprised of technologies of peptides,

peptides, oligonucleotides and oligonucleotides respectively has a technology focus score of 0.5.

Product portfolio age. This measure was constructed as the average time (in years), between the date of approval of all drugs in the pharmaceutical firm's portfolio and NPA termination. Higher values of product portfolio age imply a mature product pipeline, whereas lower values of product portfolio age imply a young product pipeline.

Product market rivalry. Product market rivalry was operationalized as a count measure of the total number of new product alliances entered by all other pharmaceutical firms in the focal therapeutic category between NPA formation and termination. This operationalization is in line with prior research (Pisano 1990). New product alliances amongst biotechnology firms were not included in the measure of rivalry because a large percentage of them still lack the capabilities to commercialize products on their own.[12]

Partner value. Partner value was operationalized as the total finances received (in $m) by the biotechnology firm as venture capital and equity between the time of the NPA formation and NPA termination.[13] The measure does not include finances received from NPAs with pharmaceutical firms. To test the U-shaped effects, a spline variable centered at the mean of the partner valuation variable was constructed.

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[12] Genentech is the only biotechnology company that has commercialized a product on its own. However, the firm relies on marketing agreements to market the product all over the world (Pisano 1990).
[13] The dollar amounts calculated in the Recap database are based on shares issued through cumulative financing and do not include options or warrant shares.

Other Variables

NPA scope. The scope of the new product alliance was operationalized as the size of the deal (in $m). This measure reflects the total resources (i.e., equity purchase, upfront payments) invested by the incumbent in the project at the time of formation.

NPD stage. The stage at which the NPA was signed was operationalized as an ordinal measure ranging from 1 to 6. Specifically, discovery alliances were coded as 1, lead molecule stage as 2, formulation as 3, phase I as 4, phase II as 5 and phase III clinical stage alliances were coded as 6.

NPA equity. A dummy variable operationalization was used to code whether the NPA involved equity. NPAs involving equity were coded as 1 and non-equity NPAs were coded as 0.

Category specific effects. It could be argued that different product categories have inherently different hazards of termination. In order to account for this category specific unobserved heterogeneity, a dummy variable operationalization was used.

Model Development

Consistent with the models used for firm failures (Kalbfleisch and Prentice 1980; Shane 2001), I test the hypotheses using a Cox proportional hazard model. The rate at which new product alliances are terminated is modeled as a function of the baseline hazard and independent variables. The baseline hazard represents the probability of termination when the covariates are zero. The covariates modify the probability of the baseline hazard in a multiplicative manner. If T_i is the time from the date of NPA formation to NPA termination, the NPA survivor function can be written as

$$S(t) = \Pr(T_i \geq t) \tag{4}$$

The hazard of termination for NPA i with event time T_i at time t can be written as:

$$h(t;xi) = \lim_{\Delta t \to 0} \frac{\Pr[t < T_i \leq t + \Delta t | T_i > t, x_i]}{\Delta t} = \frac{f(t)}{S(t)} \tag{5}$$

$f(t)$ is the probability density function,

$$h(t|X_i) = h_o(t)\exp(x_i \beta) \tag{6}$$

Where $h_o(t)$ is the baseline hazard function, x_i is the vector of independent variables/covariates for NPA i.

Since there are multiple NPAs from the same firm, there could be dependencies between termination times across observations. To account for the effect of unobserved firm covariates that might impact the baseline hazard, I add shared frailty effects to the model specification in (3). In line with prior research (Gupta 1991; Debruyne and Reibstein 2004), the frailty effects are specified as a gamma distribution as this specification has been shown to have a closed form solution. The hazard of NPA termination for NPA i involving incumbent j and new entrant k conditional on a shared frailty effect υ_j can be written as

$$h(t|X_{ijk}, \upsilon_j) = \upsilon_j h_o(t)\exp(x_{ijk}\beta) \tag{7}$$

Where the υs are independent and identically distributed gamma variates with density

$$g(\upsilon) = \frac{\upsilon^{\theta/\theta - 1} \exp(-\upsilon/\theta)}{\Gamma(1/\theta)\theta^{1/\theta}} \quad \textbf{(8)}$$

Where θ represents the heterogeneity amongst firms, with higher values of θ representing greater heterogeneity amongst sub-groups of firms and θ =0 implies no unobserved heterogeneity.

In addition, we need to account for the endogeneity of partner value because the financing received by the partner could be attributed to the focal NPA. The quality of entrepreneurial firms is not directly observable as very few of them have successfully developed new products. Therefore, investors draw inferences about the entrepreneurial firm's quality based on their innovativeness and the number of NPAs with incumbents (Nicholson, Danzon, and McCullough 2005). Accordingly, I formulate a two-stage model. Since partner value is bounded by zero, in the first stage, we estimate a Tobit regression equation that posits partner value as a linear function of the number of R&D alliances of entrepreneurial firms with incumbents and partner innovativeness until the time of NPA formation. Since the number of alliances of the partner (i.e., entrepreneurial firm) and innovativeness are measured at the time of NPA formation, these instruments are not correlated with the error of the termination equation. In the second stage, I include the fitted values of partner value from equation (6) as a regressor in equation (4) to account for the endogeneity of partner value.

$$PVALUE_{kt} = \alpha_0 + \alpha_1 NPDALL_{k(t-1)} + \alpha_2 PINNOV_{k(t-1)} + \alpha_{3-18}(X_{ijk}) + \varepsilon_{kt} \quad \textbf{(9)}$$

where *NPDALL*= number of alliances of the new entrant with incumbents at formation, *PINNOV*= number of patent citations received by the new entrant at formation.

In addition, there are ties in the NPA duration times in the data. This is because in some cases, we know the month of the termination but not the exact date. I use the Efron approximation (Efron 1977) to resolve for the unknown order of duration times.[14] The likelihood function incorporating Efron's approximation can therefore be written as

$$L(\beta|x,\upsilon) = \prod_{i=1}^{k} \frac{\exp(s_i\beta + z_i)}{\prod_{j=1}^{d} \left(\sum_{l\in R_i} \exp(x_i\beta + \upsilon_i) - \frac{(j-1)}{d_i} \sum_{l\in D_i} \exp(x_i\beta + \upsilon_i)\right)} \quad \textbf{(10)}$$

Where k is the number of distinct NPA duration times, d_i is the size of the set of D_i firms

that have terminations at time t_i, R_i is the risk set just before t_i, $s_i = \sum_{l\in D_i} x_l$ and $z_i = \sum_{l\in D_I} \upsilon_i$

RESULTS

Table 14 provides the descriptive statistics for the variables in the study. The average deal size in our sample is \$68.31m which suggests that the partnerships in the sample were substantively significant from the standpoint of the pharmaceutical firm. In addition, Table 14 suggests that the mean for *NPD Stage* is 2.63. In addition, a frequency count of early stage and late stage NPAs in the sample suggests that approximately 80% of the alliances in the sample are early stage alliances (i.e., pre-clinical trials). Also, 50%

[14] The literature on proportional hazard models advocates the use of three techniques to handle ties in the duration, namely Breslow's approximation, Efron's approximation and the exact method. The exact method is capable of handling a large number of ties and produces accurate estimates and p-values. In situations where the number of ties is moderate as in this study, the estimates and inferential statistics from Efron's approximation are reasonable (Allison 1984; Farewell and Prentice 1980).

of the NPAs in the sample are equity-based partnerships. The variance inflation factors and the condition indices for the independent variables are within acceptable levels (i.e., highest VIF is 2.56, highest condition index is 6.56) thus alleviating concerns of multicollinearity.

Since the focus of this study is on the determinants of NPA termination and not on whether the hazard of NPA termination increases or decreases over time, we employ the semi-parametric Cox proportional hazard specification. In addition, using a flexible baseline hazard allows estimation without making any distributional assumptions on the shape of the baseline hazard. Nevertheless, I plotted the baseline hazard over time. Figure 7 suggests that the baseline hazard is non-monotonic that peaks at approximately 4000 days after formation. This is in line with the fact that several drugs typically enter the clinical phases approximately 10-12 years after discovery. A key assumption of the Cox proportional hazard model is that effect of a covariate is the same at all points in time. Table 15 suggests that the test for proportional hazards using scaled Schoenfeld's residuals was not violated for any of the covariates.

TABLE 14
SUMMARY STATISTICS AND CORRELATION MATRIX: STUDY TWO

	Mean	Std.Dev	PF	TF	PPAGE	PMRIV	PVAL	SCOPE	EQUITY	STAGE	TC1	TC2	TC3	TC4	TC5	TC6	TC7	TC8	TC9	TC10
PF	0.31	0.28	1																	
TF	0.28	0.22	-0.2	1																
PPAGE	4.97	1.77	0.40	-0.50	1															
PMRIV	1.32	1.21	0.06	-0.19	0.24	1														
PVAL	20.90	53.93	0.25	-0.14	0.23	0.21	1													
SCOPE	0.68	1.25	0.42	-0.18	0.30	-0.047	0.30	1												
EQUITY	0.50	0.50	0.09	-0.02	0.04	0.13	0.13	0.11	1											
STAGE	2.63	1.67	0.15	-0.007	-0.02	-0.06	-0.04	0.19	0.05	1										
TC1	0.16	0.37	-0.13	0.04	-0.02	-0.13	-0.03	-0.07	-0.09	-0.15	1									
TC2	0.02	0.16	-0.06	-0.02	0.02	-0.05	-0.01	-0.03	0.01	-0.02	-0.07	1								
TC3	0.13	0.33	-0.07	0.01	0.00	0.08	0.03	-0.07	0.05	-0.05	-0.17	-0.06	1							
TC4	0.02	0.15	-0.05	0.00	-0.08	-0.08	-0.02	-0.03	-0.08	0.05	-0.06	-0.02	-0.05	1						
TC5	0.13	0.33	-0.01	-0.06	0.03	-0.04	-0.07	-0.03	-0.02	0.05	-0.17	-0.06	-0.15	-0.06	1					
TC6	0.06	0.25	-0.01	0.04	0.04	0.07	-0.02	-0.03	-0.08	0.00	-0.12	-0.04	-0.11	-0.04	-0.11	1				
TC7	0.19	0.39	0.14	-0.04	0.00	0.48	0.01	0.06	0.08	0.05	-0.21	-0.07	-0.18	-0.07	-0.19	-0.13	1			
TC8	0.05	0.23	-0.03	-0.00	-0.00	-0.14	0.08	0.00	0.02	0.04	-0.11	-0.04	-0.10	-0.03	-0.10	-0.07	-0.12	1		
TC9	0.07	0.26	0.07	0.04	-0.01	-0.13	0.05	0.09	0.05	0.05	-0.12	-0.04	-0.11	-0.04	-0.11	-0.08	-0.13	-0.07	1	
TC10	0.09	0.28	0.13	-0.04	0.02	-0.20	0.03	0.12	0.04	0.03	-0.13	-0.04	-0.11	-0.04	-0.12	-0.08	-0.14	-0.07	-0.08	1

PF= Product category focus, TF= Technology focus, PPAGE= Product portfolio age, PMRIV= Product market rivalry, PVAL= Partner value, SCOPE= New product alliance scope, EQUITY= Equity of the incumbent in the new product alliance, STAGE= New product alliance stage, TC1-TC10= Therapeutic categories of the new product alliance

FIGURE 7
SHAPE OF THE BASELINE HAZARD OVER TIME

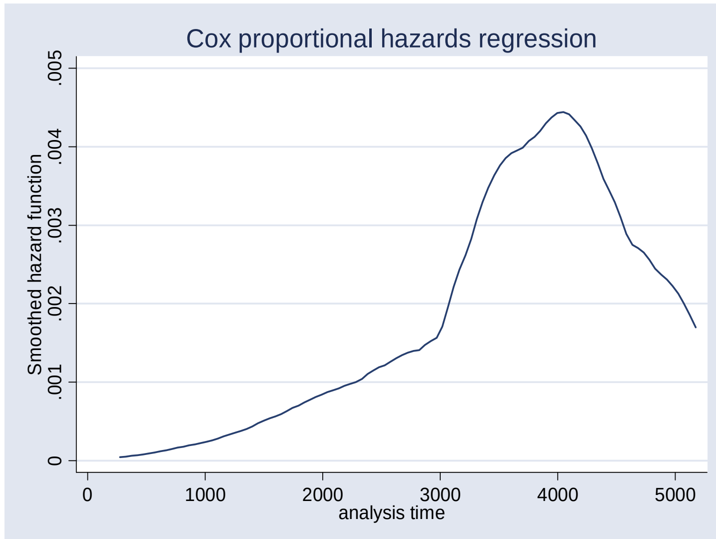

TABLE 15
TEST OF PROPORTIONALITY HAZARD ASSUMPTION

Covariates	χ^2 (d.f.)	Prob> χ^2
PCFOCUS	0.19(1)	0.66
TECHFOCUS	0.58(1)	0.44
PCFOCUS x TECHFOCUS	0.24(1)	0.62
PRODPORTAGE	0.37(1)	0.54
PRODPORTAGE x TECHFOCUS	0.47(1)	0.49
PRODMKTRIVALRY	2.35(1)	0.13
PRODMKTRIVALRY x TECHFOCUS	1.41(1)	0.23
PRODMKTFIXEDEFFECTS	7.73(9)	0.56
PVALUE (LOW)	0.33(1)	0.56
PVALUE(HIGH)	3.44(1)	0.06*
NPA SCOPE	1.10(1)	0.28
NPA EQUITY	1.05(1)	0.30
NPD STAGE	0.31(1)	0.57
Global Test	19.57(21)	0.54

p<0.10 **p<0.05 ***p<0.01

Table 16 shows the results of the first stage Tobit regression. The instruments, partner innovativeness (PINNOV) and number of R&D alliances with incumbents (NUMNPDALL) are positive and statistically significant ($p<0.01$). In Table 17, Model 1 is the base model that adds the transactional covariates and control variables to the baseline hazard. Model 2 adds firm's portfolio specific covariates (i.e., product category focus, technology focus and product portfolio age) to Model 1. Model 3, the full model adds market specific covariates to Model 2. The nested model comparisons using likelihood ratio tests suggest that NPA terminations are influenced the most by product market and partner characteristics followed by firm's portfolio characteristics and the least by the initial alliance characteristics. Models 4 & 5 test the effects of the firm's portfolio characteristics, product-market characteristics and control variables on 'unilateral terminations' and 'mutually agreed terminations' respectively. Since our objective is to understand the determinants of an incumbent's decision to terminate NPAs, we use Model 4's estimates in discussing the results. Finally, the frailty parameter (θ) is statistically significant ($p<0.05$) in all three models thus suggesting that there is a need to control for unobserved firm effects.

TABLE 16
TOBIT REGRESSION ESTIMATION RESULTS FOR PARTNER VALUE

Variable	**Parameter Estimates**
NUMNPDALLIANCES	0.98(0.17)***
PINNOVATIVENESS	5.12(0.89)***
Firm Portfolio Characteristics	
ProdCatFocus	-12.69(12.68)
TechFocus	13.36(16.98)
ProdPortAge	0.28(0.14)**
Product-market Characteristics	
ProdMktRivalry	0.06(0.02)**
Product-market Fixed Effects (Control)	0 out of 9 fixed effects significant
Alliance Characteristics	
NPA Scope	0.10(0.02)***
NPA Equity	5.95(5.36)
NPD Stage	-3.06(1.57)*
Log-likelihood	-1688.92
Number of observations	354

p<0.10 **p<0.05 ***p<0.01. The figures in parentheses are the standard error of the parameter estimates. The dependent variable is partner value in hundreds of $M.

TABLE 17
ESTIMATION RESULTS FOR COX PROPORTIONAL HAZARD MODEL WITH COMPETING RISKS

	Model 1	Model 2	Model 3	Model 4 (Unilateral Terminations)	Model 5 (Mutual Terminations)
Firm Portfolio Characteristics					
ProdCatFocus		-0.65 (0.20)**	-0.67(0.19)**	-0.78(0.22)**	-2.10(1.4)
TechFocus		1.19 (0.51)**	1.02(0.38)***	0.49(0.12)***	8.50(4.1)**
ProdCatFocus x TechFocus		1.32(1.51)	1.50(1.70)	0.20(0.14)	4.65(3.68)
ProdPortAge		-0.02(0.00)***	-0.17(0.08)**	-0.10(0.03)**	-0.31(0.21)
ProdPortAge x TechFocus		0.28(0.19)	0.52(0.36)	0.20(0.06)***	1.04(0.6)
Product-market Characteristics					
ProdMktRivalry			-1.42(0.24)***	-1.60(0.39)***	-1.32(0.36)***
ProdMktRivalry x TechFocus			-0.17(0.86)	-1.14(0.41)**	1.41(1.07)
ProdMkt Fixed Effects (Control)	3 out of 9 significant	3 out of 9 significant	3 out of 9 significant	3 out of 9 significant	2 out of 9 significant
Partner Characteristics					
Partner Value (Low)			-0.00(0.00)***	-0.53(0.10)***	-0.01(0.01)
Partner Value (High)			0.01(0.00)**	1.12(0.31)***	0.02(0.02)
Alliance Characteristics					
NPA Scope	-0.11(0.10)	-0.11(0.11)	-0.12(0.13)	-0.31(0.29)	0.00(0.15)
NPA Equity	0.13(0.20)	0.11(0.21)	0.16(0.22)	-0.16(0.29)	0.77(0.38)*
NPD Stage	0.26(0.06)***	0.25(0.06)***	0.17(0.06)***	0.22(0.08)***	0.17(0.10)*
Frailty parameter (θ)	0.16(0.07)**	0.18(0.08)**	0.24(0.07)**	0.41(0.08)***	0.13(0.11)
Log-likelihood (LL)	-530.98	-501.71	-413.28	-274.37	-178.37
Number of observations	401	401	401	401	401
Number of terminations	112	112	112	66	46

p<0.10 **p<0.05 ***p<0.01. The figures in parentheses are the standard error of the parameter estimates.

H_7 states that the hazard of NPA termination is lower for alliances with a greater overlap with firm's NPA portfolio. The results from Table 16 suggest that the parameter estimate for product category focus is negative and statistically significant (β_1=-0.78, p<0.05). H_7 is thus supported. The parameter estimate can be interpreted as follows. A one unit change in product category focus lowers the hazard of NPA termination by 55% (1-$e^{-0.43}$). Since, product category focus is scaled between 0 and 1, this implies that the hazard of termination for firms with high product category focus (PRODCATFOCUS~ 1) is 55% lower than for firms with low product category focus (PRODCATFOCUS ~ 0). H_8 states that the hazard of NPA termination is higher for alliances with a greater overlap with the firm's NPA portfolio. The parameter estimate for technology focus is positive and statistically significant (β_2=0.49, p<0.01) thus supporting H_8. Substantively, the hazard of termination for firms with high technology focus (TECHFOCUS ~ 1) is 63% higher than for firms with low technology focus (TECHFOCUS~0). Given the differential impact of product category focus and technology focus on the hazard of termination, we tested for two-way interaction between product category focus and technology focus. The interaction term was statistically insignificant (p>0.10). H_9 states that the hazard of NPA termination is lower for firms with aging product portfolios. The parameter estimate of product portfolio age is negative and statistically significant (β_4=0.10, p<0.05). Thus H_9 is supported. This implies that as the product pipeline of the firm ages by a year, the hazard of termination decreases by 9.5% (1- $e^{-0.10}$)]. However, the interaction of technology focus and product portfolio age is positive and statistically significant (β_5= 0.20, p<0.01). This suggests that regardless of the age of the product pipeline, the technological focus of the firm's NPA portfolio tends to increase the hazard of termination. H_{10} states that the hazard of NPA termination in product markets characterized by intense rivalry is lower. The parameter estimate of product market rivalry is negative and statistically significant (β_6=-1.60, p<0.01). Thus H_{10} is supported. In addition, I find that the interaction of product market rivalry and technology focus is negative and statistically significant (β_6= -1.14). This suggests that the impact of technological focus of the firm's NPA portfolio on the hazard of termination is negatively moderated by extent of rivalry in product markets. H_{11} states that the hazard of NPA termination is lowest at moderate levels of partner value. The parameter estimate for low levels of partner value is negative and statistically significant (β_9= -0.53, p<0.01) whereas the parameter estimate for high levels of partner value is positive and statistically significant (β_{10}= 1.12, p<0.01) thus lending support for H_{11}.

In addition, the results suggest that the initial alliance characteristics have relatively little influence in predicting NPA terminations. The estimates for NPA scope and NPA equity is statistically insignificant (p>0.10). However, the estimate for NPD stage is positive and statistically significant (β_9=0.22, p<0.01). Therefore, late stage NPAs have a higher hazard of termination compared to early stage NPAs. Substantively, a unit change in stage of the NPD (e.g., discovery to lead molecule, lead molecule to preclinical stage) increases the hazard of termination by approximately 25% ($e^{0.22}$-1). This is in line with the fact that a number of later stage NPAs are abandoned without receiving a marketing approval (DiMasi 2000).

As regards control variables, the parameter estimates for three out of nine therapeutic categories were statistically significant ($p < 0.05$). NPAs in the categories of central nervous system, cardiovascular and cancer have higher hazard of termination (i.e, relative to respiratory disorders). Table 18 provides a summary of the results.

TABLE 18
SUMMARY OF RESULTS:STUDY TWO

Variable	Prediction	Result	Rationale
Product category focus (H_7)	(-)	Supported	Firms with NPA portfolios focused on fewer categories have lower hazards of termination because of knowledge spillovers across projects within the category
Technology focus (H_8)	(+)	Supported	Firms with NPA portfolios focused on fewer technologies have higher hazard of termination because technology represents an exogenous source of uncertainty
Product portfolio age (H_9)	(-)	Supported	Firms with mature product pipelines have lower hazard of termination in order to avoid the losses that might accrue from co-specialized downstream assets (i.e., sales and manufacturing)
Product market rivalry (H_{10})	(-)	Supported	Firms with alliances in product markets characterized by intense rivalry have lower hazard of termination because of lack of availability of partners in the product market
Partner value (H_{11})	-/+	Supported	Partner value has a U-shaped impact on the hazard of termination. At low levels of partner value the hazard of termination is high because of the lack of external validation of the partner's NPD program. At high levels of partner value, the hazard of termination is high because greater control rights from the innovation may need to be allocated to the partner as a result of its improved financial health.

Robustness Checks

I performed several checks to ensure the robustness of the results. First, although the substantive interest is not in studying the shape of the hazard over time, I estimated a few alternate hazard models where a functional form was specified for the baseline hazard. Specifically, I estimated models with log-logistic and log-normal baseline hazards. The effects of the covariates were substantively identical across these alternate specifications. The coefficients of these alternate specifications and the Cox proportional hazard model have opposite signs. This is expected as Cox proportional models focus on the hazard rate whereas log-normal and log-logistic models use the accelerated failure time metric. Second, I estimated a split population duration model that accounts for both the timing and the incidence of terminations. The split population model was specified using a log-logistic hazard for the timing of terminations and a logit model for the incidence of terminations. Identical covariates were used for both the timing and the incidence models. The choice of a parametric duration model was dictated by the fact that split population models with unspecified baseline hazard (e.g., Cox proportional hazard model) are virtually non-existent. The results from Table 19 suggest that the splitting parameter (δ) (estimated mean probability of termination) was 0.97. Therefore, the assumption of a homogenous population in which all of the observations will experience terminations appears reasonable in this empirical context. This is in line with industry evidence that a very high percentage of NPAs between pharmaceutical firms and biotechnology firms tend to be terminated (DiMasi 2000).

TABLE 19
SPLIT POPULATION DURATION MODEL ESTIMATION RESULTS

	Timing (Log-logistic hazard model)	Incidence (Logit model)
Firm Portfolio Characteristics		
ProdCatFocus	0.16 (0.03)***	12.74 (6.50)**
TechFocus	-0.34 (0.16)**	5.76 (3.80)
ProdCatFocus x TechFocus	-0.22 (0.15)	7.8 (11.31)
ProdPortAge	0.06 (0.03)**	0.00 (0.00)*
ProdPortAge x TechFocus	-0.19(0.09)**	1.58 (0.93)
Product-market Characteristics		
ProdMktRivalry	0.72 (0.08)***	2.16 (1.94)
ProdMktRivalry x TechFocus	0.51(0.23)**	3.87(3.10)
ProdMkt Fixed Effects (Control)	2 of 9 significant	0 of 9 significant
Partner Characteristics		
Partner Value (Low)	0.45 (0.12)***	0.12 (0.14)
Partner Value (High)	-0.89 (0.45)**	-0.19 (0.12)
Alliance Characteristics		
NPA Scope	-0.02 (0.12)	-10.08 (5.51)*
NPA Equity	0.00 (0.00)	0.14 (0.10)
NPD Stage	0.02 (0.03)	7.12 (4.25)**
Log-likelihood (LL)	-545.80	
Shape Parameter	0.30 (0.03)***	
Mean Probability of Termination (δ)	0.97	

*p<0.10 **p<0.05 ***p<0.01. The figures in parentheses are the standard error of the parameter estimates

Third, it can be argued that the determinants for NPA terminations are likely to be different across different stages of the NPA. To test this possibility, I did a sub-group analysis by dividing the sample into early stage NPAs (i.e., discovery, lead molecule and formulation) and late stage NPAs (i.e., phase I, phase II, phase III). The proportion of early stage NPAs in our sample is approximately 80% whereas the remainder (i.e., 20%)

are late stage alliances. I re-estimated the model on these sub-samples. Most of the results were substantively similar across these two groups. The only exception was that product category focus had a statistically insignificant impact ($p>0.10$) on the hazard of termination for late stage alliances. This suggests that the benefits of knowledge spillovers or scope economies in late stage NPAs (i.e., management of clinical trials) perhaps accrue both within and across product categories.

THEORETICAL AND MANAGERIAL IMPLICATIONS

Implications for Research

The findings of this study have important implications for research. Firstly, I show that the decision to terminate NPAs are not made in isolation but are influenced by the structure of the firm's portfolio. Previous researchers have characterized investments in NPAs as uncorrelated choices (Kogut 1991; Park and Russo 1996). However, I find that investments in NPAs share positive and negative interdependencies with each other. Furthermore, we find that terminations are poorly predicted by the initial characteristics of the NPA. Firms that focus on NPAs in a fewer product categories have lower hazards of NPA termination. This implies that firms choose to deepen their capabilities in product markets rather than broadening their research scope in order to exploit the knowledge spillovers within the same product category, This is line with prior research that notes that a focused research program (i.e., higher Herfindahl index) increases the overall productivity of the firm's R&D efforts (i.e., important patents received) (Cockburn and Henderson 1996). However, I do not find any positive externalities for the technology platforms employed across NPAs in the portfolio. This implies that because technology is an exogenous source of uncertainty, firms explore a number of different technological paths in their search for innovative new products. Recent research examining the internal R&D performance of incumbents and new entrants, notes that incumbents experience 'hot' and 'cold' streaks in R&D output over time and that such inconsistencies impact the termination heuristic adopted (Gino and Pisano 2006; Chan, Nickerson, and Owan 2007). I test this argument in the context of an incumbent's new product partnerships and find that the hazard of NPA termination is indeed lower for firms with mature product portfolios. According to recent research, it has been argued that firms that have a high 'desperation index' because of imminent patent expirations tend to make poor acquisition choices and experience negative stock market returns (Higgins and Rodriguez 2006). Along similar lines, it can be speculated that with an aging product portfolio firms might advance even marginally economical NPAs to the next stage.

The findings suggest that NPA terminations are influenced to a greater extent by changes in the firm's product market and partner environment than by changes in the firm's alliance portfolio and product portfolio. Recently, researchers have argued that increased product-market rivalry increases the hazard of termination because the threat of preemption by competition diminishes the value of the underlying growth opportunity (Folta and Miller 2002). In contrast, I find that firms tend to hold on to NPAs in crowded product-markets. I attribute this effect to the lack of potential partners in the product market who could otherwise continue the research and development efforts for the NPA.

It is also plausible that there are 'social contagion effects' in product markets akin to what has been reported in the innovation literature (Van den Bulte and Lilien 2001; Debruyne and Reibstein 2004), although I am unable to disentangle these effects with the data.

Finally, I find that partner value has a U-shaped impact on NPA termination. There is a large stream of research that argues that changes in financing availability impacts organizational structure and outcomes (Aghion and Tirole 1994; Lerner, Shane, and Tsai 2003). This paper takes an initial step in linking the fluctuations in the financing environment of partners to termination outcomes. I find that when partners are able to raise significant amount of equity from external investors, they renegotiate the terms of the contract thereby diminishing the value of the NPA to the incumbent. .

Implications for Practice

The findings of this study have important implications for managing new product alliances. It is well-recognized that firms need to adopt a portfolio mindset in managing new product alliances and go beyond individual deals. According to Gomes-Casseres (2002), managing new product partnerships goes beyond striking deals and includes managing the portfolio over time to see how it's growing, which alliances tend to be the most beneficial and which could be closed and how resources should be allocated. Using a portfolio approach to NPAs, this study identifies NPAs that share positive and negative interdependencies with other NPAs in the incumbent's portfolio. Therefore, managers attending to the transactional features of the NPA in deciding which NPAs to continue/discontinue are likely to be making sub-optimal decisions. This is indeed echoed in the sentiments of the chief financial officer (CFO) of Merck who observes that when managers frequently face the decision of whether to continue to invest in a drug development program, options analysis provides the needed flexibility that traditional analysis based on net present value (NPV) may not provide (Nichols 1994).

Are product–markets and technologies employed for innovation sources of uncertainty that needs to balanced through diversification? The results are indicative of important differences between product markets and technologies. Firms that focus on fewer product markets stand to gain because of knowledge spillovers across R&D alliances. In contrast, NPAs employing the same technologies are substitutes. These two findings imply that firms employing a diverse set of technologies in fewer product markets could balance risk and exploit knowledge externalities, although I did not find support for this effect. As regards product portfolio effects, I find that the hazard of NPA terminations is lower for firms with aging product pipelines. In such situations, firms face the danger of advancing marginally economical NPAs to the next stage and increasing the overall costs of NPD.

The results also point to the need for firms to pay close attention to competitor activity in the focal product-market as it provides useful insights regarding the availability of potential R&D partners in the product market. In addition, firms also need to track the financing markets in the industry as it indicates whether partners will succeed in raising capital from external investors. This is important as the findings suggest that the partners that can strengthen their financial position after the formation of the NPA could potentially destabilize the NPA.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study, like any empirical endeavor has certain limitations that future research could address. First, although the empirical context of this study is the biopharmaceutical industry, findings are generalizable to other high-technology industries where investments are characterized by a great deal of uncertainty (e.g., semiconductors, information technology). Future research could test the generalizability of the findings in alternate empirical contexts. Second, in the absence of performance data on NPAs, the findings are descriptive rather than normative. Third, this study does not account for the incumbent's internal R&D efforts in various product markets. Future research could explore whether firm's internal R&D portfolios influence the terminations of NPAs. A fourth limitation of the study relates to the unavailability of data on the potential market size of the various therapeutic categories. Future research that explicitly account for how changes in market size impact the firm's NPA portfolio management strategy can shed additional insights. This would entail getting relevant data on demand-based market size measures because market size measure based on drug sales is endogenous (i.e., better drugs have higher sales). Examining the relationship between incumbent's termination decisions and its financial performance is an important avenue for future research.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The ubiquity of NPD alliances between "unequals" in high technology industries can be attributed to the fact that neither larger firms nor smaller firms are able to muster all of the resources needed to develop, manufacture, and market products on their own. In this dissertation, I examine two important issues pertaining to the formation and termination of asymmetric NPD alliances. Although, such alliances frequently conjure up images of 'David versus Goliath' at first glance, the results from study one show that value is created for both the partners. More importantly, I find interesting asymmetries in the magnitude and drivers of the changes in the values for the larger and the smaller partner firms, offering valuable insights.

New product alliances are clearly vital for innovation in high technology industries. However, greater number of NPAs in one's portfolio does not necessarily increase the odds of success. The challenge for firms is to balance resources with opportunities, identify winners, weed out losers and redeploy resources as priorities shift. In study two, I develop and empirically test a framework of the determinants of NPA terminations. The results suggest that NPA terminations evolve with changes in the firm's alliance and product portfolio. I also find that NPA terminations are predicted to a great extent by competition in product markets and changes in the alliance partner's financial conditions. The findings of this study hold the potential to spawn a stream of research on the dynamics of NPA termination and its financial consequences.

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APPENDIX 1

COMPUTATION OF NPV OR SHORT-TERM ABNORMAL RETURNS

The market model for the event study is given by:

$$R_{kt} = \alpha_k + \beta_k R_{mt} + \varepsilon_{kt} \quad \textbf{(11)}$$

where R_{kt} denotes the daily returns of k^{th} firm in the NPD alliance at time t, measured over a 240-day window, $\alpha_{k,}\beta_k$ are firm-specific parameters, R_{mt} is the daily return on the CRSP equally-weighted market index, and ε_{kt} is an error term assumed to be distributed i.i.d. normal. Furthermore,

$$\hat{R}_{kt} = \hat{\alpha}_k + \hat{\beta}_{kt} R_{mt} \quad \textbf{(12)}$$

The abnormal return (AR) and cumulative abnormal return (CAR), are thus given by:

$$AR_{kt} = R_{kt} - \hat{R}_{kt} \quad \textbf{(13)}$$

$$CAR_{kt(-1,1)} = \sum_{t=-1}^{1} AR_{kt} \quad \textbf{(14)}$$

Because stock prices are strongly correlated with firm size, to control for this size effect, I compute the net present value accruing to the partner firm as the product of cumulative abnormal returns over the event window and the market capitalization of the firm. In line with previous research, I computed the market capitalization of the firm as the product of the firm's share price and number of outstanding shares 20 days prior to the alliance announcement (Chan et al 1997, p. 210).[15]

[15] In the event that the market was closed for trading 20 days prior to the announcement date, the previous trading day was selected to retrieve the share price and the number of outstanding shares of the firm.

The *NPV* of firm k following the NPD alliance announcement at time t is operationalized as

$$NPV_{kt} = NSHARES_{k(t-20)} P_{k(t-20)} CAR_{kt(-1,1)} \quad \textbf{(15)}$$

where $NSHARES_{k(t-20)}$ = Number of outstanding shares of firm k 20 days prior to the event, $P_{k(t-20)}$ = Firm k's stock price 20 days prior to the event, and the other terms are as defined earlier.

APPENDIX 2

ROBUSTNESS CHECKS

I performed several robustness checks. First, a common criticism of the event study methodology is that the results are sensitive to the chosen event windows. To alleviate this concern, I calculated the financial gains by using the cumulative abnormal returns over different event windows (e.g., -3 to +3, -5 to + 5). The substantive results of the analysis remain unchanged across the event windows.

Second, an emerging body of research in finance and in marketing (e.g., Fama and French 1993; Lyon, Barber, and Tsai 1999; Sorescu, Shankar, and Kushwaha 2007) contends that because stock markets are at best semi-efficient, there is a need to examine the long-term (typically 12 months after the event) stock performance especially if short-term gains are insignificant. The results show that short-term financial gains are significant for both larger and smaller firms. Nevertheless, consistent with studies of long-term returns, I performed calendar-time portfolio regressions to assess the long-term stock performance (see Appendix 3 for details). The results of this analysis show that the long-term abnormal returns accruing to both the larger and smaller firms, although significant, are marginal, confirming that the gains are mainly short-term. Thus, these results rule out the possibility of long-term performance reversals.

Third, I checked whether the results are robust to alternative operationalizations of firm size. I operationalized firm size in terms of the number of employees and sales revenues. These alternative operationalizations did not alter the patterns of asymmetry in the NPD alliance. Furthermore, the results for the hypothesized effects did not change substantively regardless of the firm size measures employed. Fourth, additional robustness checks for asset size ratios (of larger to smaller firm) greater than 6, 8, and 10 did not alter the substantive results, although the standard errors were inflated because of reduced sample size.

Fifth, to check if there are spillover or feedback effects of changes in shareholder values of the larger and the smaller firm on each other, I estimated a simultaneous equation model using two stage least squares (2SLS), three stage least squares (3SLS), and generalized method of moments (GMM) methods. The effect of the change in shareholder value of each type of firm on the change in the shareholder value of its partner firm did not turn out be significant, so the proposed model was retained.

Sixth, it can be potentially argued that the smaller firm gains more than the larger firm because of anticipation on the part of the investors that the smaller firm might be acquired by the bigger firm. To rule out this possibility, I examined the data for acquisitions. Only three alliances in the data resulted in an acquisition of the smaller firm by the larger firm. I re-estimated the model by excluding these three alliances, but the substantive results remained unchanged.

Finally, I performed additional analyses to check if alliance characteristics result in value changes for the combined portfolio of larger and smaller firms. The results suggest that alliance type and alliance scope did not have statistically significant effects on the combined wealth change of the partner firms ($p > 0.10$). However, the interaction of alliance type and alliance scope had a statistically significant effect on the combined financial gains ($p < 0.05$). Thus, these results suggest that scale alliances that are of broad scope enhance the combined wealth of the partner firms.

APPENDIX 3

LONG-TERM RETURNS FOR PARTNER FIRMS IN AN ALLIANCE

The commonly used approach in the event study literature to examine long-run abnormal returns is the buy-and-hold abnormal returns method. However, this method is unable to control for cross-sectional dependence and often yields inflated test statistics (Lyon, Barber and Tsai 1999). A second approach that controls for cross-sectional dependence is based on calendar-time portfolios (e.g., Fama and French 1993; Sorescu, Shankar, and Kushwaha 2007). In this approach, the sample firms are grouped into portfolios based on the event date and the inference is based on a time series of the mean abnormal return of the portfolio.

I used the Fama-French three factor model to compute the one-year long run abnormal returns. I used the calendar-time return on a portfolio of firms created on the basis of the event date to estimate the following regression:

$$R_{pt} - R_{ft} = \alpha_p + \beta_p (R_{mt} - R_{ft}) + \gamma_p SMB_t + \delta_p HML_t + \varepsilon_{it} \qquad \textbf{(16)}$$

where R_{pt} is the simple returns of the calendar-time portfolio p at time t, R_{ft} is the return on three-month treasury bills, R_{mt} is the return on the value-weighted market index, SMB is the difference in the returns of the portfolio of small stocks and big stocks, HML is the difference in the returns of the portfolio of high book-to-market stocks and low book-to-market stocks, and ε is the error term.. The intercept is the mean monthly abnormal returns on the calendar-time portfolio. The results for larger and smaller firms are shown below.

TABLE 20
LONG-TERM ABNORMAL RETURNS FOR LARGER FIRMS: CALENDAR-TIME PORTFOLIO REGRESSIONS

Coefficient	Average month in (-12, 12)	OLS t-statistic	Heteroskedasticity consistent t
α_p (Abnormal return)	0.01	2.23*	2.27*
β_p	1.21	13.64***	11.07***
δ_p	0.21	2.52*	1.94+
γ_p	- 0.70	- 6.76***	- 6.01***
R^2	0.79		

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

TABLE 21
LONG-TERM ABNORMAL RETURNS FOR SMALLER FIRMS: CALENDAR-TIME PORTFOLIO REGRESSIONS

Coefficient	Average month in (-12, 12)	OLS t-statistic	Heteroskedasticity consistent t
α_p (Abnormal return)	0.00	2.21*	2.08*
β_p	1.58	8.70***	8.48***
δ_p	1.14	6.15***	4.80***
γ_p	- 1.16	- 5.08***	- 4.01***
R^2	0.71		

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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