Project Scope, Market Size Prospects, and Launch Outcomes in Cooperative New Product Development

Kimberly M. Green
University of West Georgia

This study investigates the relationship between the number of partners in cooperative new product development and the scope of the development project, the projected market size for the product, and the likelihood the product will be launched. With drug development in the pharmaceutical industry as the setting, the hypotheses are tested using hierarchical modeling and a dataset of 7,167 drugs across 86 firms during the period 1995 – 2006. Results suggest that the number of development partners is positively related to the scope of knowledge categories underlying the development effort, while the scope of product applications is associated with market size.

INTRODUCTION

A new product development (NPD) process is a driver of firms' future growth prospects and competitive positioning. Yet the process is complex and subject to considerable risk. Consequently, many firms opt to work with partners, even though sharing the downside also necessitates sharing the upside. Cooperating firms share the risks and costs of development but also share resources, knowledge, and the payoff from NPD. While cooperative development allows firms to share risk, it adds a risk that a firm's knowledge could be misappropriated by partners. Additionally, cooperative arrangements require monitoring and management if the benefits are to be realized.

Existing research on cooperative development has examined both the performance of specific alliances and of a firm's set of alliances in general. Studies suggest that factors such as the relative size of the firms, the type of information they are attempting to share, and the structure of the alliance provide insight into the performance of individual cooperative arrangements (Bierly & Coombs, 2004; Powell, 1998; Stuart, 2000). At the firm-level, research has noted that some firms excel in their ability to manage the complexity of choosing partners and oversee multiple relationships, exhibiting an alliance management or partnering capability (Rothaermel & Deeds, 2006). Further, a study of pharmaceutical firms found that the number of partners a firm has is related to the firm's total number of drugs on the market (Rothaermel & Deeds, 2004). Research examining the number of alliances has considered the overall performance of the product development portfolio, but we have a more limited understanding of the relationship between the number of partners working on a specific project and the characteristics and outcomes of that project. What relationship, if any, exists between the number of partners and the scope and outcome for each individual product development initiative? And, given that partners share the payoff, is the number of partners associated with the market potential for a product? To consider whether the complexity of managing the cooperative arrangement is associated with the likelihood of launching a product, the study examines the relationship between the number of partners participating in the

development of one product and whether or not the product launches. The present study takes the product-level perspective and uses biopharmaceutical product development – i.e., drugs – as the context.

THEORY AND HYPOTHESES

This study is based in the cooperative development research of the new product development literature. Themes from existing research that form the foundation for the present study include the motivations for entering product development alliances and the management of those alliances. Firms will form alliances to gain access to a variety of resources, either tangible such as funding, or intangible, such as skills that cannot be developed internally, network connections, an endorsement or reputation by association, and knowledge or expertise (Gerwin & Ferris, 2004; Powell, 1998; Stuart, 20000). Regarding the management of alliances, research considers both the management of all of a firm's alliance activity as well as the structure and coordination of activities with individual alliance partners. Researchers focusing on the firm's set of alliances, or "portfolio of coalitions," have reported that the relationship between the number of alliances and the level of new product development exhibits diminishing returns (Rothaermel, 2001). An increase in the number of a firm's cooperative arrangements is initially associated with an increased level of output as the number of a firm's cooperative arrangements increases. Coordination of an increasing number of alliances eventually becomes more difficult, and returns diminish. Studies addressing the level of the individual alliance report that factors such as the relative size of the firms (Powell, 1998; Stuart, 2000) and the type of information they are attempting to share have been used to explain variations in cooperative arrangements.

Pharmaceutical data are useful for investigating each of three broad stages of innovation and new product development (Henderson & Cockburn, 1994; Roberts & McEvily, 2005): discovery, development, and commercialization. The first stage is the research or discovery process in which potentially effective therapies and compounds are identified as viable candidates to proceed to the development stage for testing. Next, the development process involves the testing of products and selection of those that will be launched for sale in the market and use by consumers. The final stage is the post-launch performance, with success in this stage being defined as commercial successes. Although the examples used to describe these stages are specific to pharmaceuticals, the stages have parallels in other industries. The study proposed herein concentrates on the middle stage, or the development of the new product from the time it is identified as a potentially viable candidate up until the point of launch.

Project Scope

The scope of a product development effort can be manifest in more than one way. This study considers that scope may indicate the number of different knowledge categories that developers draw on or scope may indicate the number of different uses for a product that the developers test and attempt to incorporate. The larger the scope of the product development effort, the greater may be the required resource commitment to see the project through. Partnerships can provide access to those needed resources (Gerwin & Ferris, 2004). Research suggests that there are returns to scope but not to scale in drug development efforts (Cockburn & Henderson, 2001) and that focusing on only a few fields can make high-quality patents increasingly difficult to obtain (Lin & Chen, 2005). Consequently, firms may make use of alliances and cooperative development in pursuit of these benefits of scope, accessing partners' knowledge rather than relying solely on knowledge bases of their own. Research has also shown that firms tend to use narrower pipelines than they should in their product development efforts (Ding & Eliashberg, 2002). Using development partners may allow the firm to expand either the number of products or the scope of individual products in development. For example, partners could test alternative product uses in parallel development efforts while a firm acting alone might have to experiment with alternative uses sequentially due to capacity or time bottlenecks with their employees, facilities, or budget allocations. Based on this logic, the number of development partners would be expected to be positively related to project scope. This study tests two operationalizations of project scope:

H1a: The number of development partners for a product is positively related to project scope when scope is conceptualized as the number of different knowledge bases underlying the project.

H1b: The number of development partners for a product is positively related to project scope when scope is conceptualized as the number of alternative uses for the product. (i.e., the number of conditions the drug is intended to treat).

Projected Market Size

By providing access to knowledge and experience, alliances may allow for the development of products that have more extensive market appeal than a firm could realize if working alone. Partners may vary in their knowledge of the science, the market, and the development process. Partners with varied experience may recognize a different target market. In the case of products subject to governmental regulation such as pharmaceuticals, partners may have better access to and understanding of the approval process in different countries. Alliances have been linked to speed of development when there is similarity and overlap in the knowledge bases of the firms (Rindfleisch & Moorman, 2001). Having partners may help to speed launch-date estimates so that the product is on the market generating sales revenues for a longer time while still protected by patent. If market size is measured in revenues, the number of partners could, then, be positively associated with market size. Additionally, partners may be chosen for their reputation (Stuart, 2000). A positive reputation can help to expand sales prospects for products such as pharmaceuticals, for instance, when sales depend on prescriptions or recommendations from physicians who may rely on the reputation of one or more partners or on positive prior experience with other products from those partners. Researchers have also noted that the development of innovative products benefits from the generation of a high number of creative ideas and that a greater number of ideas are generated collaboratively (Alves, Marques, Saur & Marques, 2007).

H2a: The number of development partners for a product is positively related to projected market size measured in sales revenue.

With its choice of knowledge bases that drive development or the alternative uses to be tested, a firm designs a product intended to meet the needs of a target market. A drug that is developed to treat multiple medical conditions is a product serving multiple customer segments and is an example of technology leveraging. As technology is exploited in an increasing number of markets, the value extracted from the technology increases (Allen, 2003). Even if some knowledge categories that are explored or alternative uses that are tested do not succeed and are not incorporated into the final version of the launched product, the lessons learned from those failed explorations may contribute to making the launched product better and more useful for customers.

Research suggests that planning and controls, budgets and milestones facilitate the success of product development (Davila, Foster, & Li, 2009). Demand and revenue estimates are critical because significant development costs must be incurred before any revenue is realized (Allen, 2003). Product design may be revised and scaled back if the original design proves too expensive relative to the estimated market size. Market projections can be adjusted as new information either resolves or reveals uncertainty in the environment, leading to revised resource allocation to product development projects (Anderson & Joglekar, 2005).

H2b: The project scope is positively related to projected market size measured in sales revenue.

Product Launch

Both physical and knowledge resources may be shared in cooperative arrangements, and both can contribute to improving the chances of launching a product. New product development is a costly process.

Partners can bring funding, facilities, or employees to contribute to the effort. The intangible knowledge resources may include technological expertise, product-market knowledge, or skills with the process of development. While some firms simply want access to a partner's knowledge, others may seek to acquire and internalize knowledge learned from the partner (Mowery et al., 1996). In either case, the knowledge shared when collaborating on a new product could improve the chances for successfully developing and launching that product. The partners may also create knowledge and, together, craft a new approach that is different from, and perhaps superior to, the approach that either partner might have pursued alone (Berends, van der Bij, Debackere & Weggeman, 2006). Research has shown that products developed in an alliance have a higher probability of success (Danzon et al., 2005). These points suggest that the chances for successful development of the product should be higher as the number of development partners increases:

> *H3: The number of development partners for a product is positively related to the likelihood that the product will be launched.*

METHODS

The data for this study are drawn from the ADIS R&D Insight database of drug development. This database is a product of Wolter Kluwers Health and is designed to provide insight into the drug development pipelines of companies in the biopharma industry, both for competitive intelligence purposes and for identifying possible partners for co-development or candidates for licensing. Because the database covers the development pipeline, it includes not only drugs on the market (i.e., launched) but also drugs under development and drugs for which development has been discontinued/canceled. This insight into not only successful NPD efforts (i.e., launched products) but also failed efforts is useful for furthering our understanding of the NPD process specifically and corporate innovation more generally. For a subset of drugs in the database, an assessment of market potential is provided by market analysts prior to the drug's launch. The data for the present study are drawn from the 1995 – 2006 time period during which the market analysis was provided by Lehman Brothers. This time period precedes both the uncertainties introduced by United States' healthcare reform and the financial crisis and resulting recession that affected banks such as Lehman Brothers. For this study, data on the variables of interest are available for approximately 7,167 drugs in the portfolios of 86 companies. The subset having market analysts' estimates includes 920 drugs in the portfolios of 71 companies. The data will be analyzed using hierarchical linear modeling (HLM) to account for the nesting of products (drugs) within companies.

Operationalization of Variables

Descriptions of the variables, explanations of the calculations, and the rationale for each operationalization are included below.

Number of Different Product Uses

The number of different product uses represents the scope of the development project. In this study, the number of different indications for a drug is used as the measure of the number of different product uses. The number of indications is the number of unique conditions that a drug is intended to treat. As an example, the drug Entecavir is being tested for two different indications – Hepatitis B and Herpesvirus infections. This drug has two indications, regardless of whether it is actually launched to treat both or not.

Number of Knowledge Categories

The number of knowledge categories is represented by the number of different therapeutic categories that underlie the drug. Standardized categories are used by the pharmaceutical industry to classify drugs based on the conditions they are intended to treat and their chemical composition (Nerkar & Roberts, 2004). The Adis R&D Insight database reports the World Health Organization's Anatomical Therapeutic Chemical (WHO-ATC) class for each drug. This classification system divides the drugs into groups

according to the organ or system on which they act and their chemical, pharmacological and therapeutic properties. The WHO-ATC classification consists of five levels of increasing specificity. There are fourteen Level 1 classes or main groups (World Health Organization, 2013). Examples include category A = alimentary tract and metabolism, B = blood and blood forming organs, and N = nervous system. For the purpose of this study, the Level 1 classification is used to define the therapeutic categories because the categories are sufficiently different from each other to capture specialized and non-overlapping knowledge. The number of therapeutic classes for a drug is, therefore, the number of different Level 1 classes for all of the indications. A larger number of knowledge categories indicates greater scope.

Projected Market Size

Investment banks employ analysts who typically specialize in an industry and focus on one or a few companies, providing forecasts of future earnings and drivers of those earnings. The Adis R&D Insight database reported analysts' estimates of market size potential for certain drugs in the portfolios of companies tracked by analysts at Lehman Brothers bank for the years of this study (1995 – 2006). This time period precedes both the uncertainties introduced by the United States' healthcare reform and the financial crisis and resulting recession that affected banks such as Lehman Brothers. These sales revenue projections consider each drug's expected launch date, time remaining until the patent expires, the various geographic regions in which the drug will be distributed, and various partners licensing or distributing the drug. Market size is measured as projected sales revenue in the peak year (in $US).

Likelihood that a Product is Launched

The likelihood that a product is launched is a dichotomous variable coded as 1 if the product has launched and 0 if the product has been discontinued without launch. If the drug has not yet been launched for any indication or has not been discontinued for all indications, this drug is considered to be still under development (i.e., the development outcome has not yet been decided) and the value for this variable is missing. A discontinued drug is any drug having a status in the Adis database of Discontinued, No Development Reported, Suspended, or Withdrawn.

Number of Partners

For each drug that involved collaboration, the database lists these partner organizations and identifies whether they are originating companies or licensing companies. The partners may be either pharmaceutical firms or private organizations such as research hospitals or universities. The count of organizations listed as originating companies for a drug is the *number of development (or originating) partners* for that drug. The count of organizations listed as licensing companies for a drug is the *number of licensing partners* for that drug.

Control Variables

Other variables will be included in the analysis to control for possible alternative explanations for the hypothesized relationships.

Firm Size

The relationship of firm size to concepts important to the likelihood of launching a drug and to expecting sizeable revenue has been noted in numerous studies. For example, large firms might have a higher likelihood of success because they may be better able to afford the specialized equipment that is often required by different therapeutic categories (Graves & Langowitz, 1993). Larger firms may have larger chemical libraries that serve as a source of advantage in generating more viable drug candidates for the development process (Thomke & Kuemmerle, 2002). Economies of scale may favor large firms, but their size may also make them more subject to the effects of inertia (Hauser et al., 2006). Small firms are associated with more innovative products and large firms are associated with less innovative products (Kotabe & Swan, 1995). Firm size is measured as the number of employees.

Firm Age

Because experience accumulates over time, older firms will have had more time to build knowledge than younger firms. Firm age has been linked to a firm's ability to innovate (Hauser et al., 2006). Age in alliances has been found to influence performance in cooperative development (Deeds & Rothaermel, 2003). Firm age is measured as the years since the firm's founding date or date of incorporation when the founding date is not available.

R&D Intensity

Firms with a high level of drug development activity might have a higher likelihood of launch or stronger candidates for high revenue, blockbuster drugs not because they are accumulating knowledge and building competences in particular therapeutic categories but because their higher expenditures for R&D include higher salaries that enable them to attract the best scientists (Henderson & Cockburn, 1994). R&D intensity is measured on an annual basis as the firm's R&D expenditures for the year divided by the annual sales revenue. Calculated in this manner, this variable indicates those firms that allocate a relatively greater proportion of their revenues to R&D efforts.

Number of Drugs in the Pipeline

Research has found that R&D productivity is subject to economies of both scale and scope (Henderson & Cockburn, 1996). The number of drugs in the firm's pipeline is a count including all drugs under development.

ANALYSIS AND RESULTS

The data have a hierarchical or multi-level structure since each product is associated with a firm. Individual product observations within the same firm are subject to common firm effects and, therefore, may not be independent. If not taken into account, dependence among individual observations can lead to misestimated standard errors in the statistical analysis. Hierarchical linear modeling helps resolve this problem by incorporating a unique random effect for each organizational unit and taking the variability in these random effects into account in estimating the standard errors (Raudenbush & Bryk, 2002). The hierarchical linear modeling estimates for this study were computed using HLM 6.03.

TABLE 1
HIERARCHICAL LINEAR MODELING ESTIMATES FOR HYPOTHESES 1a AND 1b

Dependent Variable (Poisson distribution):	**Number of Knowledge Categories (H1a)**		**Number of Product Uses (H1b)**	
	Model 1	Model 2	Model 1	Model 2
Firm-Level (Level 2) Controls:				
Intercept (β_0)	0.308** (0.967)	0.237* (0.095)	0.308** (0.967)	0.612** (0.174)
Firm Size[a] (employees)	0.009 (0.027)	0.009 (0.027)	0.009 (0.027)	-0.013 (0.045)
Firm Age[a] (years)	-0.045 (0.051)	-0.042 (0.050)	-0.045 (0.051)	-0.044 (0.088)
R&D Intensity	-0.008 (0.006)	-0.008 (0.006)	-0.008 (0.006)	-0.016 (0.010)
Pipeline (number of products under development)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)
Product-Level (Level 1) Independent Variable:				
Number of Development Partners		0.059** (0.019)		0.061 (0.040)

[a] The natural log of firm size and firm age are the variables used in the analysis.
HLM2 final estimates with robust standard errors. Unstandardized coefficients are reported; standard errors are in parentheses.
The number of level 1 units (drugs) = 7,167 and the number of level 2 units (companies) = 86.
† $p < 0.10$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Because the measures of product scope that serve as dependent variables in hypotheses 1a and 1b are count measures, the analysis of these hypotheses uses a Poisson distribution. Table 1 reports the results of the analysis. The firm-level control variables are entered in Model 1, and the product-level independent variable is entered in Model 2. For hypothesis 1a, product scope is operationalized as the number of different anatomical-therapeutic categories that the drug development efforts tap into. The positive and significant coefficient for the relationship between the number of originating partners and the number of different categories ($p < 0.01$) offers support for hypothesis 1a. In hypothesis 1b, product scope is presented as the number of different conditions for which the drug is investigated as a possible treatment. This analysis does not provide support for hypothesis 1b, since the relationship between the number of originating partners and the number of different conditions investigated is not significant.

TABLE 2
HIERARCHICAL LINEAR MODELING ESTIMATES FOR HYPOTHESES 2a AND 2b

Dependent Variable:	**Projected Market Size (Revenues)**				
	Model 1	Model 2	Model 3	Model 4	Model 5
Firm-Level (Level 2) Controls:					
Intercept (β_0)	1971.250*** (524.445)	2229.692*** (555.306)	454.545 (544.960)	510.396 (395.049)	484.150 (462.478)
Firm Size[a] (employees)	251.716 (208.202)	240.992 (209.687)	146.022 (184.314)	145.123 (167.140)	116.148 (159.419)
Firm Age[a] (years)	-662.392 (275.160)	-685.946* (276.214)	-116.470 (270.803)	-147.374 (208.476)	-83.468 (228.899)
R&D Intensity	-71.229† (39.858)	-74.024† (39.922)	-9.750 (35.046)	-9.546 (24.154)	-1.245 (27.912)
Pipeline (number of products under development)	1.129 (2.126)	1.408 (2.133)	0.896 (1.893)	0.323 (1.933)	0.889 (1.526)
Product-Level (Level 1) Independent Variables:					
H2a: Number of Development Partners		-195.308** (68.686)			-154.676† (79.805)
H2b: Number of Knowledge Categories			385.627** (121.524)		71.705 (145.231)
H2b: Number of Alternative Product Uses				190.678*** (37.631)	178.057*** (42.172)

[a] The natural log of firm size and firm age are the variables used in the analysis.
HLM2 final estimates with robust standard errors. Unstandardized coefficients are reported; standard errors are in parentheses.
The number of level 1 units (drugs) = 920 and the number of level 2 units (companies) = 71.
† $p < 0.10$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

The dependent variable for hypotheses 2a and 2b is projected market size, a continuous variable. Table 2 reports the results of this analysis, with firm-level control variables presented in Model 1 and the product-level independent variables entered in Models 2 – 5. As noted in the table, the sample size for this part of the analysis is smaller than the tests of other dependent variables because the investment analysts' assessment of market size was not provided for all drugs in the dataset. Hypothesis 2a predicted a positive relationship between number of originating partners and the projected market size. However, the negative coefficient in Model 2 ($p < 0.01$) and the moderately significant negative coefficient in the full model 5 ($p < 0.10$) suggest a negative relationship between these variables. Both operationalizations of product scope were used to test hypothesis 2b. While the number of different anatomical-therapeutic categories is

significant in Model 3 ($p < 0.01$), it is not significant in the full model 5. The number of different indications that the drug is investigated to treat is significant in both its individual model 4 ($p < 0.001$) and in the full model 5 ($p < 0.001$). These results offer partial support for hypothesis 2b.

The dependent variable for hypothesis 3 is a dichotomous variable that has a value of 1 if the product has been launched for any of its indications and a value of 0 if the product has been discontinued for all indications. The results of the analysis, shown in Table 3, show no significant relationship between number of originating partners and the likelihood of the product launching.

TABLE 3
HIERARCHICAL LINEAR MODELING ESTIMATES FOR HYPOTHESIS 3

Dependent Variable (Dichotomous):	**Likelihood of Product Launch**	
	Model 1	Model 2
Firm-Level (Level 2) Controls:		
Intercept (β_0)	-1.717*** (0.479)	-1.825*** (0.471)
Firm Size[a] (employees)	0.241 (0.185)	0.232 (0.168)
Firm Age[a] (years)	0.220 (0.300)	0.181 (0.282)
R&D Intensity	0.039 (0.028)	0.034 (0.026)
Pipeline (number of products under development)	-0.008*** (0.002)	-0.007*** (0.002)
Product-Level (Level 1) Independent Variables:		
Number of Development Partners		0.154 (0.116)

[a] The natural log of firm size and firm age are the variables used in the analysis.
HLM2 final estimates with robust standard errors. Unstandardized coefficients are reported; standard errors are in parentheses.
The number of level 1 units (drugs) = 5,493 and the number of level 2 units (companies) = 85.
† $p < 0.10$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Ad Hoc Analysis

Researchers have suggested that certain alliances are primarily exploratory while others are primarily exploitative (Rothaermel & Deeds, 2004). Using this distinction, the number of originating partners measured in this study could be considered principally exploratory. A separate group of partners – those who participate in licensing arrangements with the originators – might tend to be more exploitative in purpose. Therefore, ad hoc analyses were performed to consider the number of licensing partners as an independent variable related to (1) projected market size and (2) likelihood of launch. Licensees may expand the reach of the product by, for instance, serving specific geographic regions with which the originating partners have limited familiarity or putting more resources behind the launch and more quickly scaling up distribution. The results, shown in Table 4, indicate that the number of licensing partners is positively related to the projected market size with a positive and significant coefficient in Model 1 ($p < 0.01$) when the number of licensing partners is tested separately and a moderately significant coefficient in Model 2 ($p < 0.10$) when it is tested in the presence of the other independent variables analyzed earlier as predictors of market size. When the likelihood of launch is the dependent variable, the coefficient for the number of licensing partners is positive and significant ($p < 0.001$).

TABLE 4
RESULTS OF AD HOC REGRESSION ANALYSES

Dependent Variables:	**Projected Market Size (Revenues)**		**Likelihood of Product Launch**	
	Model 1	Model 2	Model 1	Model 2
Firm-Level (Level 2) Controls:				
Intercept (β_0)	1295.367***	533.658	-2.535***	-2.539***
	(373.766)	(344.448)	(0.528)	(0.482)
Firm Size[a] (employees)	80.483	36.848	0.489**	0.495**
	(134.634)	(128.242)	(0.182)	(0.165)
Firm Age[a] (years)	-439.934*	-133.141	0.112	0.076
	(187.052)	(167.094)	(0.325)	(0.289)
R&D Intensity	-73.013*	-19.372	0.057†	0.058*
	(35.484)	(26.765)	(0.031)	(0.028)
Pipeline (number of products under development)	3.597*	2.152*	-0.006*	-0.007**
	(1.417)	(1.081)	(0.003)	(0.002)
Product-Level (Level 1) Independent Variable:				
Number of Licensing Partners	232.963***	117.911†	1.417***	1.101***
	(55.189)	(62.513)	(0.092)	(0.076)
Number of Development Partners		-121.899†		0.230†
		(63.755)		(0.116)
Project Scope: Number of Different Knowledge Categories		60.815		
		(116.222)		
Project Scope: Number of Alternative Product Uses		135.809**		
		(46.899)		

[a] The natural log of firm size and firm age are the variables used in the analysis.
HLM2 final estimates with robust standard errors. Unstandardized coefficients are reported; standard errors are in parentheses.
For models with Market Size as the DV, the number of level 1 units (drugs) = 920 and the number of level 2 units (companies) = 71. For models with Launch as the DV, the number of level 1 units (drugs) = 5,493 and the number of level 2 units (companies) = 85.
† $p < 0.10$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

DISCUSSION AND CONCLUSION

This study investigates the relationship between the number of partners in cooperative new product development and the scope of the development project, the projected market size for the product, and the likelihood the product will be launched. While cooperation can increase the physical and knowledge resources available for the development effort, it may also increase the complexity due to the coordination required and the potential exposure of proprietary knowledge. Therefore, deepening our understanding of how the number of development partners might be associated with various dimensions and outcomes of individual product development initiatives can contribute to the effective management of product development.

The results of the tests of H1a and H1b suggest that the number of development partners is associated with project scope when scope is measured as the number of knowledge categories (H1a) that underlie the development initiative. This result is consistent with the idea that different partners bring different bases of knowledge and experience to the collaboration. The result indicating that the number of different product uses being tested is not significantly related to the number of development partners may indicate that firms do not necessarily need to have partners in order to identify and test multiple uses for a product. The different knowledge bases that can be offered by multiple partners, for instance, might be needed for

developing complex or innovative products. But a firm may be able to test multiple alternative uses alone. These results are also consistent with the idea that collaborative efforts may be circumscribed and specific, carefully identifying the contributions expected by the partners and the uses to which those contributions are to be applied. Partners bring diverse knowledge bases to apply to specific product uses. For example, research has found that, at various points in the relationship between two partners, they will write more restrictive, detailed documents governing the relationship (Li, Eden, Hitt & Ireland, 2008).

The tests of H2a and H2b considered whether the number of development partners and project scope are related to the projected market size, when market is measured in revenues. The moderately significant and negative relationship between number of partners and projected market size indicates that market size increases as the number of partners decreases. This finding is consistent with the logic that a greater number of partners increases the complexity of coordination efforts which may slow down the pace of development for some projects, limiting the revenue potential especially for products using a patented technology. The two measures of project scope taken together offer additional insight. While the number of underlying knowledge categories is not significant, the number of different product uses is significantly related to projected market size. The market sees and responds to the distinct applications for the product, with the product having wider appeal to different customers with different needs. The underlying knowledge categories required to develop those different uses would not necessarily be known or understood by the customers. The knowledge from different categories could prove to be either completely redundant and not incrementally useful or so distant and disconnected that synergies cannot be captured.

The result of the test of H3 indicates that the likelihood of a product being launched is not related to the number of partners involved in developing the product. This result is consistent with the idea that managing alliances is complex and, therefore, some can be managed productively while others may not be able to coordinate efforts effectively to yield a product. This result is also consistent with the hit-rate argument about innovation which argues that firms who have more products on the market do not have higher success rates than other firms, they merely make more attempts or take more turn at-bat (Morris & Kuratko, 2002). Firms with many partners may not have any greater likelihood of success than firms with fewer partners or those acting alone. This result may also be indicative of a strategy of development partners pursuing multiple projects, and then canceling those that show less promise and continuing with those that have greatest potential. Thus, a higher number of development partners could be associated with more attempts but not with an improved likelihood of launch for any particular product. In this same vein, Rothaermel and Deeds (2004) suggested that products on the market (i.e., products launched) is predicted by exploitation alliances, which would be licensing partners rather than development partners since development is interpreted as more exploratory. Based on this observation from prior research, the number of licensing partners was included in an ad hoc analysis.

The ad hoc analysis that added the number or licensing partners as a variable explaining projected market size reports a moderately significant relationship between these variables. This finding is consistent with research indicating that, when performance is measured in terms of new product development, firms focusing their alliance strategy on exploitation outperform those focusing on exploring (Rothaermel, 2001). An interesting comparison here, though, is that exploitation is often associated with incremental rather than radical innovation, suggesting products that are not dramatic improvements beyond what is already on the market (Atuahene-Gima, 2005). If customers do not see sufficient reason to switch, incremental improvements may not attract a sizeable market. Consequently, are the licensing partners in-licensing radical or incremental innovations that are associated with these higher projected market sizes? These points suggest that exploration/exploitation may be measured at the development stage and again at the sales and distribution stage. Do development partners undertake exploration to develop products that will attract many new customers, followed then by licensing partners exploiting competencies in in-licensing technology or distribution skills?

Limitations, Implications, and Future Research

A discussion of the contributions and implications of this research must acknowledge its limitations. First, the study's focus on a single industry may limit the generalizability of the results. However, concentrating on a single industry serves to control for industry-specific effects such as patenting strategies, regulatory environment, phases of development, and knowledge categories such as the anatomical-therapeutic categories that, in this case, can be consistently applied across all pharmaceutical firms. Second, although the dataset includes development projects existing during the span of years 1995 - 2006, the variables are measures specific to individual drugs rather than to a sequence of time. Therefore, the analyses can test only for correlations and not for causal relationships. We can, for example, hypothesize that the number of licensing partners would contribute to a larger projected market size. However, it could also be the case that a larger projected market size attracts a larger number of licensing partners and those partnerships form because the revenue expectations are sufficient to support that larger number of partners. Third, the investment analysts' estimates of market size are not available for all drugs. Further, these estimates include only revenues and not profits, as it is typical for companies not to reveal the costs or expected returns from individual projects. However, profit projections could differ greatly for two products that are expected to generate similar levels of total revenue, and such differences could affect launch decisions and collaboration strategies.

The results of this study have implications for both the theory and the practice of management. The number of originating partners is positively related to the number of knowledge categories, suggesting that firms do use alliances as a source of knowledge. However, the number of alternative product uses rather than the number of knowledge categories is positively associated with projected market size. This finding suggests that while the strategy of cooperative development may generate products with sizeable revenue projections, many firms may also choose strategies such as acquiring a firm with necessary knowledge or developing the requisite skills internally by hiring employees. Firms often acquire companies they have partnered with in the past, having used the partnership to test the potential for success of an acquisition. Future research could address how companies strike an optimal balance between projects they pursue independently and those they pursue cooperatively. What characteristics of the projects or the firms determine this optimal balance?

The number of development partners is negatively associated with projected market size and demonstrates no association with likelihood of launch in this dataset. Taken together with the finding that the number of alternative product uses is positively associated with projected market size, these results are consistent with research that firms' product development efforts benefit not only from breadth of knowledge, which might be obtained by increasing the number of partners, but also from depth of knowledge, which could be developed independently as firms exploit synergy among products in the same category (Sorescu, Chandy & Prabhu, 2003). The knowledge complementarity or redundancy that has been linked to product creativity (Rindfleisch & Moorman, 2001) can be obtained by working with a smaller number of firms, perhaps those with competency in the same categories. Further, this study has considered the number of development partners as a variable explaining the likelihood of launch of products in general. It could be the case that products with particular characteristics will benefit more from a larger number of partners.

The finding that the number of licensing partners was positively related to projected market size suggests that there is substantial money at stake in forming these alliances. Finding appropriate licensing partners and setting appropriate fees and stipulations will be important to the successful realization of the revenues. Existing research has found that firms' general alliance experience has a positive relationship with project outcomes while partner-specific experience has a negative relationship (Hoang & Rothaermel, 2005). This idea, in conjunction with the results of the present study, suggests that future research could consider how firms optimally use a large number of partners while relying little on building partner-specific experience. As the number of partners increases, do firms use a mix of prior partners and new partners in efforts to gain from their generalized alliance experience rather than relying repeatedly on known partners?

NPD can shape new industries and drive the profitability of individual firms. Since new products are developed to satisfy unmet needs in the market, they have the potential to make a difference both for the customers and for the firm that is successful in navigating the complexities of the NPD process. The NPD process can be long, particularly so in the biopharmaceutical industry, and require heavy investment today for an uncertain payoff well into the future. Understanding what factors are related to success with product development efforts can be a source of competitive advantage for firms that regularly and repeatedly undertake to develop new products. The present study contributes to this understanding by examining how cooperative development shapes the outcomes in NPD efforts.

REFERENCES

Allen, K.R. (2003). *Bringing New Technology to Market*. Upper Saddle River, NJ: Prentice Hall.

Alves, J., Marques, M.J., Saur, I., & Marques, P. (2007). Creativity and Innovation through Multidisciplinary and Multisectoral Cooperation. *Creativity and Innovation Management*, 16, (1), 27-34.

Anderson, E.G., & Joglekar, N.R. (2005). A Hierarchical Product Development Planning Framework. *Production & Operations Management*, 14, (3), 344-361.

Atuahene-Gima, K. (2005). Resolving the Capability-Rigidity Paradox in New Product Innovation. *Journal of Marketing*, 69, October, 61-83.

Berends, H., van der Bij, H., Debackere, K., & Weggeman, M. (2006). Knowledge Sharing Mechanisms in Industrial Research. *R&D Management*, 36, (1), 85-95.

Bierly, P.E., III, & Coombs, J.E. (2004). Equity Alliances, Stages of Product Development, and Alliance Instability. *Journal of Engineering and Technology Management*, 21, 191-214.

Cockburn, I.M., & Henderson, R.M. (2001). Scale and Scope in Drug Development: Unpacking the Advantages of Size in Pharmaceutical Research. *Journal of Health Economics*, 20, 1033-1057.

Danzon, P.M., Nicholson, S., & Pereira, N.S. (2005). Productivity in Pharmaceutical-Biotechnology R&D: The role of Experience and Alliances. *Journal of Health Economics*, 24, 317-339.

Davila, A., Foster, G., & Li, M. (2009). Reasons for Management Control Systems Adoption: Insights from Product Development Systems Choice by Early-Stage Entrepreneurial Companies. *Accounting, Organizations & Society*, 34, (3/4), 322-347.

Ding, M., & Eliashberg, J. (2002). Structuring the New Product Development Pipeline. *Management Science*, 48, (3), 343-363.

Graves, S.B., & Langowitz, N.S. (1993). Innovative Productivity and Returns to Scale in the Pharmaceutical Industry. *Strategic Management Journal*, 14, (8), 593-605.

Hauser, J., Tellis, G.J., & Griffin, A. (2006). Research on Innovation: A Review and Agenda for *Marketing Science*. *Marketing Science*, 25, (6), 687-717.

Henderson, R., & Cockburn, I. (1994). Measuring Competence? Exploring Firm Effects in Pharmaceutical Research. *Strategic Management Journal*, 15, (Winter Special Issue), 63-84.

Henderson, R., & Cockburn, I. (1996). Scale, Scope, and Spillovers: The Determinants of Research Productivity in Drug Discovery. *RAND Journal of Economics*, 27, (1), 32-59.

Hoang, H., & Rothaermel, F.T. (2005). The Effect of General and Partner-Specific Alliance Experience on Joint R&D Project Performance. *Academy of Management Journal*, 48, (2), 332-345.

Kotabe, M., & Swan, K.S. (1995). The Role of Strategic Alliances in High-Technology New Product Development. *Strategic Management Journal*, 16, (8), 621-636.

Li, D., Eden, L., Hitt, M.A., & Ireland, R.D. (2008). Friends, Acquaintances, or Strangers? Partner Selection in R&D Alliances. *Academy of Management Journal*, 51, (2), 315-334.

Lin, B.W., & Chen, J.S. (2005). Corporate Technology Portfolios and R&D Performance Measures: A Study of Technology Intensive Firms. *R&D Management*, 35, (2), 157-170.

Morris, M.H., & Kuratko, D.F. (2002). *Corporate Entrepreneurship*. Fort Worth, TX: Harcourt.

Mowery, D.C., Oxley, J.E., & Silverman, B.S. (1996). Strategic Alliances and Interfirm Knowledge Transfer. *Strategic Management Journal*, 17, Winter Special Issue, 77-91.

Nerkar, A., & Roberts, P.W. (2004). Technological and Product-Market Experience and the Success of New Product Introductions in the Pharmaceutical Industry. *Strategic Management Journal*, 25, 779-799.

Powell, W.W. (1998). Learning from Collaboration: Knowledge and Networks in the Biotechnology and Pharmaceutical Industries. *California Management Review*, 40, (3), 228-240.

Raudenbush, S.W., & Bryk, A. (2002). *Hierarchical Linear Models: Applications and Data Analysis Methods* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Rindfleisch, A., & Moorman, C. (2001). The Acquisition and Utilization of Information in New Product Alliances: A Strength-of-Ties Perspective. *Journal of Marketing*, 65, (2), 1-18.

Roberts, P.W., & McEvily, S. (2005). Product-Line Expansion and Resource Cannibalization. *Journal of Economic Behavior & Organization*, 57, 49-70.

Rothaermel, F.T. (2001). Incumbent's Advantage through Exploiting Complementary Assets via Interfirm Cooperation. *Strategic Management Journal*, 22, 687-799.

Rothaermel, F.T., & Deeds, D.L. (2004). Exploration and Exploitation Alliances in Biotechnology: A System of New Product Development. *Strategic Management Journal*, 25, (3), 201-221.

Rothaermel, F.T., & Deeds, D.L. (2006). Alliance Type, Alliance Experience and Alliance Management Capability in High-Technology Ventures. *Journal of Business Venturing*, 21, 429-460.

Sorescu, A.B., Chandy, R.K., & Prabhu, J.C. (2003). Sources and Financial Consequences of Radical Innovation: Insights from Pharmaceuticals. *Journal of Marketing*, 67, October, 82-102.

Stuart, T.E. (2000). Interorganizational Alliances and the Performance of Firms: A Study of Growth and Innovation Rates in a High-Technology Industry. *Strategic Management Journal*, 21, (8), 791-811.

Thomke, S., & Kuemmerle, W. (2002). Asset Accumulation, Interdependence and Technological Change: Evidence from Pharmaceutical Drug Discovery. *Strategic Management Journal*, 23, 619-635.

World Health Organization Collaborating Centre for Drug Statistics Methodology. (2013). The Anatomical Therapeutic Chemical (ATC)/ Defined Daily Dose (DDD) Classification System Index. Retrieved from the Web January 30, 2013. http://www.whocc.no/atc_ddd_index/