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RESEARCH NOTE

INCUMBENT'S ADVANTAGE THROUGH EXPLOITING COMPLEMENTARY ASSETS VIA INTERFIRM COOPERATION

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I examine interfirm cooperation between incumbents and new entrants as a mechanism for incumbents to adapt to radical technological change through exploitation of complementary assets. The research setting is the biopharmaceutical industry, where I analyze 889 strategic alliances between 32 large pharmaceutical firms and providers of the new biotechnology. I find that incumbents that focus their network strategy on exploiting complementary assets outperform incumbents that focus on exploring the new technology. However, there are limits to this strategy due to diminishing marginal returns to alliance intensity. I am also able to show that an incumbent's new product development is positively associated with its performance.

Incumbent firms often face severe difficulties in adapting to radical technological change (Foster, 1986). The advent of the personal computer (PC), for example, destroyed the demand for a wide array of products ranging from typewriters to fully dedicated word-processing systems, while at the same time it created huge opportunities for new PC manufacturers, their suppliers, and the producers of complementary products like software and printers. Thus, radical innovations often initiate a Schumpeterian process of creative destruction, leading to the replacement of incumbents by new entrants. Schumpeter asserted that this perennial gale of creative destruction is the driving force behind the market system:

> The process of Creative Destruction is the essential fact about capitalism … it is not [price] competition which counts but the competition from … *new technology* … competition which strikes not at the margins of profits … of existing firms but at their foundations and their very lives. (Schumpeter, 1942: 83–84; italics added)

However, not every radical technological breakthrough will produce a process of creative destruction in which new entrants rise to dominance as incumbents fail. Incumbent firms may be able to adapt to radical technological change if they have the necessary financial and managerial resources to master such an adaptation (Christensen and Bower, 1996). For example, the emergence of the Internet is considered to be a radical innovation for firms in the computing industry; however, the dominant software enterprise in the pre-Internet era, Microsoft, has embraced this technological shift and incorporated it throughout its business. Likewise, IBM is emerging as a leading e-business infrastructure provider. What these incumbents have in common is that they did not develop the new technology, but they gained access to it through licensing agreements, strategic alliances, joint ventures, and acquisitions.

Key words: strategic alliances; complementary assets; technological discontinuity; biopharmaceutical industry
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Therefore, the phenomenon of extensive cooperation between incumbents and new entrants following radical technological change warrants more attention. Understanding how incumbent firms may take advantage of technological discontinuities is becoming more and more important as the new competitive landscape is characterized by an increasing speed and magnitude of technological change (Bettis and Hitt, 1995). Incumbent survival in the face of radical technological change has been explained by the persistence of market capabilities (Abernathy and Clark, 1985), prior collaborative relationships (Mitchell and Singh, 1996), and complementary assets (Tripsas, 1997). In addition, it has been shown that incumbents are able to thrive on technological change as long as it is competence enhancing (Tushman and Anderson, 1986) or sustaining in nature (Christensen and Bower, 1996). More research, however, is needed to understand the phenomenon of interfirm cooperation between incumbents and new entrants following a technological discontinuity, and its subsequent impact on incumbent performance.

The contribution of this paper lies in creating links between interfirm cooperation, new product development, and incumbent firm performance in the post-innovation time period. I focus on incumbent firms exposed to radical technological change and analyze how they have used interfirm cooperation with new entrants as a strategy not only to adapt but also to innovate successfully. In particular, I attempt to show how corporate entrepreneurship (Zahra, 1993; Covin and Miles, 1999) pursued by large pharmaceutical firms has led to the successful adaptation to a radical innovation—in this case, the emergence of biotechnology as the new framework of drug discovery and development.

It has long been proposed that corporate entrepreneurship leads to superior firm performance (Guth and Ginsberg, 1990). Few studies have empirically tested this proposition (cf. Zahra and Covin, 1995). This study of 889 strategic alliances between large pharmaceutical companies and new biotechnology firms provides one of the few attempts to empirically test the impact of corporate entrepreneurship on firm performance. What is unique about this study is the attempt to integrate the literatures on technology innovation, strategic alliances, and corporate entrepreneurship.

RADICAL TECHNOLOGICAL CHANGE AND INCUMBENT PERFORMANCE

Teece (1986) argued that the ownership of complementary assets, particularly when they are specialized to the commercialization of an innovation, determines who will benefit from that innovation. Incumbents with competencies in manufacturing or marketing are often well positioned to benefit from technological change, even if it is radical in nature. Tripsas (1997), for example, was able to show that complementary assets buffered incumbents in the typesetter industry from the consequences of radical technological change. Thus, Teece (1986) posited that the fully integrated incumbent is the firm best positioned to benefit from innovation through exploitation of existing complementary assets. The commercialization of the CAT scan highlights this view. GE did not invent the CAT scan; however, it soon became the market leader, since it possessed the complementary assets necessary to succeed in this new market. On the other hand, the innovator, EMI, was unable to acquire or develop the needed complementary assets to successfully commercialize the CAT scan and eventually exited the market.

Others argue, however, that dynamic networks allow firms to focus on their core competencies through partnering with other firms along the industry value chain (Miles and Snow, 1986). Interfirm networks can improve an incumbent's access to emerging technologies, increase opportunities for organizational learning, and enable rapid adaptation to market and technology shifts (Gulati, 1998). In addition, interfirm cooperation may allow firms to generate relational rents which they would not be able to generate in isolation (Dyer and Singh, 1998). Mohr and Spekman (1994) in their study of strategic alliances in the computer industry found that a network strategy can lead to a competitive advantage.

Hypotheses development

Strategic alliances and new product development

A firm exposed to radical technological change must assemble the necessary technological and nontechnological value chain activities to commercialize the new technology successfully

(Pavitt, 1998). Radical new technologies are generally pioneered by new entrants (Tushman and Anderson, 1986). New entrants, however, may find it necessary to cooperate with incumbent firms in order to commercialize the new technology, i.e., to gain access to the market and to capital, in particular when forward integration is difficult and capital is scarce (Pisano, 1991). In addition, new entrants may be further motivated to cooperate with incumbents as alliances with established firms can bestow legitimacy, and thus positive reputational effects (Stuart, Hoang, and Hybels, 1999). Incumbents, on the other hand, often prefer cooperative arrangements over the acquisition of new entrants in order to internalize the new technology and thus maximize the value of their real options, particularly in environments of high uncertainty (Folta, 1998).

Williamson (1985) has pointed out that extensive cooperation between incumbent and new entrant firms may ensue in the context described above. Generally, the new entrants discover and develop new products based on the radical new technology, while the incumbents commercialize the new products. These partnerships allow new entrants and incumbents to focus on their respective specialized skills and capabilities. As a result, incumbent firms that possess downstream value chain activities specific to commercializing a new technology may be able to adapt to radical technological change through strategic alliances with new entrants. At the same time, new entrants are able to extend their downstream value chains and increase the likelihood that their innovative output will be commercialized successfully, by accessing the market-oriented competencies of incumbent firms. Thus, complementary assets form the basis for a specialization-based division of labor in commercializing a radical new technology (Teece, 1992). Interfirm cooperation driven by access to complementary assets should be positively associated with the new product development for incumbent firms since it allows incumbents to commercialize the innovative output developed by new entrants.

Interfirm cooperation, however, is motivated not only by access to mutually complementary assets, but also by learning (Powell, Koput, and Smith-Doerr, 1996). Firms may enter into strategic alliances to learn the new technology from their partners and, in turn, enhance their own competencies in new product development. Based on the notion that strategic alliances are driven by complementarities and organizational learning, I argue that the number of strategic alliances an incumbent firm has formed with providers of the new technology should have a positive effect on the incumbent's new product development. Strategic alliances may create unique resource combinations that, if valuable, rare, and difficult to imitate, can form the basis for a competitive advantage (Barney, 1991).

However, the more alliances an incumbent firm participates in simultaneously, the higher the probability that management will be less effective in managing those alliances due to bounded rationality (Simon, 1960). An increasing number of alliances creates increasing managerial information-processing demands, which may contribute to an overall negative net effect at high levels of alliance intensity (Hitt, Hoskisson, and Kim, 1997). Further, with an increasing number of alliances, an incumbent firm's transaction costs may rise up to and possibly beyond a point where gains from additional alliances are outweighed by their costs (Jones and Hill, 1988). Since in every firm there is a limit to managerial and financial resources, the relationship between an incumbent's strategic alliances and its new product development will exhibit diminishing marginal returns and, past some point, diminishing total returns. In other words, the relationship has an inverted-U shape.

> *Hypothesis 1: The relationship between an incumbent's strategic alliances with providers of the new technology and the incumbent's new product development is curvilinear, i.e., the relationship exhibits diminishing marginal returns and, past some point, diminishing total returns.*

Exploration vs. exploitation alliances

Exploration is understood as 'the pursuit of knowledge, of things that might come to be known,' and *exploitation* as 'the use and development of things already known' (Levinthal and March, 1993: 105). Applying March's (1991) dichotomy of exploration and exploitation to a firm's strategic alliances, an incumbent firm can theoretically enter two types of alliances with new entrants: *exploration* and *exploitation* alliances (Koza and Lewin, 1998). I argue that

organizational learning motivates exploration alliances, while access to complementarities motivates exploitation alliances. Nonetheless, both types of alliances should improve the product development of incumbent firms because incumbents may build new competencies through exploration alliances or leverage existing competencies through exploitation alliances.

On the one hand, an incumbent firm can enter into strategic alliances to learn the new technology (exploration alliances), allowing it to build new upstream value chain activities (Hagedoorn and Schakenraad, 1994). This type of alliance allows partners to get close enough to share tacit knowledge such as basic R&D (Lane and Lubatkin, 1998). An example of an exploration alliance is the alliance between the 'incumbent' IBM and the 'new entrant' Microsoft with the goal of developing a new standard of operating system (OS/2) for personal computers in the mid 1980s. Mowery, Oxley, and Silverman (1996) found support for the notion that exploration alliances allow the acquisition of new capabilities, in particular, when the alliances are structured as joint ventures.

On the other hand, an incumbent firm can enter into alliances to leverage existing complementary assets (exploitation alliances) that allow the incumbent firm to benefit directly from the technological expertise of the new entrant. Exploitation alliances focus on complementarities among the allied partners as they exchange explicit knowledge (Teece, 1992). The new entrant provides the new technology, while the incumbent commercializes it. The collaboration in the telecommunications industry between Cincinnati Bell, an 'old' Regional Bell Operating Company, and several new cellular service providers exemplifies the nature of exploitation alliances. Cincinnati Bell was able to build a profitable business by performing all of the customer care functions, including billing and service inquiries, for these new entrants.

I argue that both exploration and exploitation alliances are antecedents of an incumbent's new product development. Exploration alliances are predictors of new product development since exploration alliances are explicitly entered with the goal of discovering or developing a new service or product. The issue of causality is less clear with respect to exploitation alliances. Exploitation alliances usually start with an R&D project that has been brought to technological completion but has not yet been commercialized. Exploitation alliances still contain some residual uncertainty because the incumbent generally needs to bring the new product through the commercialization stages of the value chain, for example, obtaining government approval, if necessary, and involving marketing and sales.

Even though exploration alliances generally carry more uncertainty than exploitation alliances, exploitation alliances are not without risk. In particular, many new products need regulatory approval before they can be introduced into the market. Johnson & Johnson, for example, has created its Ethicon division to focus on exploitation alliances with providers of a new technology. The goal is to license-in promising technologies from new ventures and research institutions like universities to commercialize them (Cohan, 1997). In this scenario, Johnson & Johnson still bears the residual uncertainty of commercialization, including that of obtaining FDA approval. Following Schumpeter's (1934) definition of innovation as commercialized invention, only when the approval is granted and the product has been commercialized can one count this product as a firm-level innovation and new product development.

Empirical research indicates that the success rate of major product launches is somewhere between 14 and 20 percent (Stevens and Burley, 1997; Griffin, 1997). The high failure rate of innovation in the post-technological completion stage is a result of market uncertainty, poor commercialization, poor positioning strategy, technological myopia, market timing, and regulatory uncertainties (Brown and Eisenhardt, 1995). While these numbers do not differentiate with respect to the organizational arrangement of the innovation, I argue that they provide some evidence that exploitation alliances do bear residual uncertainty and can be reasonably viewed as antecedents of new product development.

I further argue that an incumbent's exploitation alliances have a greater impact than its exploration alliances on the incumbent's new product development because of the different degrees of uncertainty they carry. If an incumbent's technological value-chain activities are depreciated by the new technology and its complementary assets remain intact, it is beneficial for the incumbent to focus its network strategy on exploitation

alliances. In this case, the incumbent commercializes the products developed by new entrants. The goal of exploration alliances, on the other hand, is to develop new, unknown products. Both the new entrant and incumbent pursue new knowledge with a highly uncertain outcome. Since the level of uncertainty is generally lower in exploitation alliances than in exploration alliances, I expect exploitation alliances to have a stronger impact on the incumbent's new product development in the post-innovation time period.

Hypothesis 2: Following radical technological change, an incumbent's exploitation alliances have a greater impact than its exploration alliances on the incumbent's new product development, when the incumbent firm possesses complementary assets necessary to the commercialization of the new technology.

New product development and firm performance

Radical technological change in combination with intensified global competition characterizes the competitive environment in many industries (Bettis and Hitt, 1995). Such an environment places a premium on a firm's capability to innovate and to introduce new products or services into the marketplace (Franko, 1989). I argue that an incumbent's strategic alliances with new entrants are a way for the incumbent to adapt to radical technological change and subsequently to improve its performance through the successful commercialization of new products.

Covin and Miles defined corporate entrepreneurship as 'the presence of innovation plus the objective of … purposefully redefining organizations, markets, or industries in order to create or sustain competitive superiority' (Covin and Miles, 1999: 50). Thus, new product development and commercialization by incumbents helping to adapt to a new technological paradigm are considered to be a manifestation of corporate entrepreneurship. Zahra and Covin (1995) found corporate entrepreneurship, operationalized as innovation and new product development, was associated with superior firm performance. Likewise, Wiklund (1999) found a positive and sustainable relationship between firms' entrepreneurial orientation and their performance.

New product introductions may allow the innovator to establish first mover advantages and a temporary monopoly (Lieberman and Montgomery, 1988). This is particularly true in industries where standards or effective patent protection create winner-take-all scenarios (Hill, 1997). Even in other types of industries, successful new product introductions still allow the first mover to benefit from early market preemption, reputation effects, and experience curve effects (Lieberman and Montgomery, 1988).

Hypothesis 3: An incumbent's new product development is positively associated with its performance.

METHODS

Sample and research setting

The sample for this study consists of 32 large pharmaceutical companies that have entered into 889 strategic alliances with providers of the new biotechnology. The research setting is the biopharmaceutical industry. This term describes the industry composed of traditional pharmaceutical companies, such as Merck or Eli Lilly, that utilize biotechnology for drug discovery and development, as well as fully dedicated biotechnology firms, such as Amgen or Genentech, and nonprofit research institutions and universities engaged in biotechnology research. The unit of analysis is the incumbent pharmaceutical firm as it attempts to adapt to the new biotechnology via interfirm cooperation with providers of the new biotechnology.

The emergence of biotechnology can be interpreted as a radical process innovation that broke the barriers to entry into the pharmaceutical industry (Stuart *et al.*, 1999). Consequently, many new biotechnology firms emerged to commercialize this technological breakthrough. Between the mid 1970s and 1997, over 1100 new entrants entered the industry to commercialize biotechnology, the majority with a focus on human therapeutics (BioScan, 1997).

The upstream value chain activities in research, drug discovery, and drug development based on chemical synthesis deployed by traditional pharmaceutical companies have been rendered largely obsolete within the new biotechnology paradigm. The skill loss for a scientist making the transition from the traditional chemical-based framework to the new biotechnology framework

is estimated to be 80–100 percent based on the semi-structured interviews conducted for this study. Nevertheless, the downstream value chain activities of incumbent pharmaceutical firms, such as FDA regulatory management, and marketing and sales, retained their value in this new environment. The challenge for incumbents has been to fit the new technologies based on recombinant DNA into their existing value chains; this has largely been attempted via interfirm cooperation with new entrants (Rothaermel, 2000). Consequently, the biopharmaceutical industry exhibits the highest alliance activity among all the industries studied in prior research (Hagedoorn, 1993).

Data

I constructed a data base containing 889 strategic alliances between incumbents and new entrants dating from the emergence of biotechnology in the mid 1970s to 1997 based on the following sources: BioScan industry directory, Scrip's Yearbooks on the global pharmaceutical industry, and the annual biotechnology industry reports published by Ernst & Young and Burrill & Company. These sources were complemented by data obtained from Standard & Poor's monthly industry reports and the Compustat as well as Bloomberg's data base. I augmented the secondary data with 15 semi-structured interviews conducted with executives (including CEOs), board members, managers, and scientists in the biopharmaceutical industry.

I identified the chemical-based, traditional pharmaceutical firms active in biotechnology listed under Standard Industrial Classification (SIC) code 2834 'Pharmaceutical Preparations.' I then cross-referenced and complemented the SIC-2834 industry sample with Scrip's Yearbooks on the global pharmaceutical industry and with BioScan. The final sample comprises 32 large pharmaceutical firms, which participated in 889 strategic alliances focused on biotechnology for drug discovery, development, and commercialization.

Measures

An incumbent pharmaceutical firm's *new product development* based on biotechnology is the dependent variable to test Hypotheses 1 and 2. I operationalized this variable by the number of new biotechnology products the firm had introduced into the market up until December 1997 (which marks the publication date of the BioScan industry directory used for this study). New biotechnology products include new biotechnology-based drugs, such as Hoffman-La Roche's Roferon-A for chronic myelogenous leukemia or Bristol-Myers Squibb's Zerit for HIV, and *in vivo* diagnostics. These therapeutics are placed inside the human body (*in vivo*) as opposed to *in vitro* drugs or diagnostics that are used outside the human body. I chose to limit the sample to *in vivo* therapeutics as the firms engaged in this segment of biotechnology are exposed to extensive regulatory requirements which demand detailed reporting about each specific drug or diagnostic.

An incumbent's *firm performance* is the dependent variable to test Hypothesis 3. To measure firm performance, I constructed a financial performance index for each firm based on its average firm ROE for 1998 and 1999. I further controlled for a potential specification bias arising from unobserved heterogeneity through the inclusion of 1997 firm ROE as independent variable (*lagged firm performance*) when testing Hypothesis 3 (Jacobson, 1990).

The number of *strategic alliances* is a count variable of the strategic alliances a traditional pharmaceutical firm has entered into with providers of biotechnology. I further split the total number of alliances into *exploration* and *exploitation* alliances. BioScan has a qualitative section for each firm describing its alliances in detail. Each alliance is classified along the value chain of a fully integrated biopharmaceutical company. I coded technology-oriented alliances that focus on drug discovery and development, as well as clinical and commercial manufacturing, as exploration alliances. Market-oriented alliances that focus on clinical trials, FDA regulatory management, and marketing and sales, were coded as exploitation alliances.

I calculated the *average age of the alliances* and their subcategories (exploration and exploitation alliances) to control for age dependency. I controlled for *equity alliances* (strong ties) vs. *nonequity alliances* (weak ties) through the inclusion of the ratio of equity alliances over nonequity alliances. I controlled for incumbent *firm size* using the logarithm of 1997 firm rev-

enues. I further controlled for potential *economies of scope* based on technological diversity of incumbent pharmaceutical firms through a count variable that represents the number of biotechnology subfields in which the pharmaceutical firm participates (Shan, Walker, and Kogut, 1994). Finally, I controlled for institutional differences by including an indicator variable *country* distinguishing between U.S. and non-U.S. pharmaceutical companies (Hennart, Roehl, and Zietlow, 1999).

The hypotheses were tested using multivariate regression models. Since the dependent variable (*new product development*) for testing Hypotheses 1 and 2 is an integer count variable, OLS estimates of the regression coefficients would have been asymptotically biased and inconsistent (Greene, 1997). To test these hypotheses, I chose a negative binomial regression model with a maximum likelihood estimation procedure over a Poisson model since equality of mean and variance is not present in the sample (Kogut, Shan, and Walker, 1992). For Hypothesis 2, I additionally applied a *t*-test for the difference between partial regression coefficients (Cohen and Cohen, 1983). Hypothesis 3 was tested using OLS.

RESULTS

The 889 strategic alliances split into 317 exploration and 589 exploitation alliances. Only 17 alliances were targeted towards both. This small number of alliances (1.9%) that span the entire industry value chain lends support to March's (1991) view of exploration and exploitation as relatively distinct and separate firm activities. All 589 exploitation alliances were nonequity alliances, while the 317 exploration alliances split into 234 nonequity and 83 equity alliances. Descriptive statistics and the bivariate correlation matrix can be found in Table 1. Tables 2 and 3 depict the regression results.

Model 1 represents the base model, which includes the control variables only. Hypothesis 1 states that the relationship between the number of an incumbent's strategic alliances with providers of the new technology and the incumbent's new product development is curvilinear. I find support for Hypothesis 1. In Model 2, which shows a significant improvement over the base model ($p < 0.01$), the coefficient *total number of strategic alliances* is positive, as expected, and statistically significant ($p < 0.001$), while the coefficient *total number of strategic alliances squared* is negative, as expected, and statistically significant ($p < 0.05$).

Hypothesis 2 indicates that an incumbent firm's exploitation alliances have a greater impact on the incumbent's new product development than its exploration alliances. Model 3 (linear alliance variables only) and Model 4 (full model, including squared alliance variables) pitch exploration and exploitation alliances directly against one another and show that exploitation alliances have a stronger positive impact on an incumbent's new product development than its exploration alliances. Applying a *t*-test for the difference between partial regression coefficients shows that the respective difference between the coefficients for exploration and exploitation alliances is statistically significant ($p < 0.001$) in both models. Models 5 and 6 indicate a significant improvement over the base model ($p < 0.05$ and $p < 0.001$ respectively). In sum, I find strong support for Hypothesis 2.

Hypothesis 3 states that an incumbent's new product development is positively associated with its performance. Model 5 represents the base model, which includes the control variables only. Model 6, which represents a significant improvement over the base model ($p < 0.05$), shows that the coefficient *new product development* is positive and statistically significant ($p < 0.05$) in explaining firm performance. Thus, I find a positive association between an incumbent firm's new product development and its performance.

DISCUSSION AND CONCLUSION

The emergence of biotechnology can be understood as a radical process innovation in the way drugs are discovered, developed, and manufactured for firms within the traditional, chemical-based pharmaceutical framework (Stuart *et al.*, 1999). However, the emergence of biotechnology has not led to the destruction of existing pharmaceutical companies. Rather, we are witnessing a transformation of the traditional, chemical-based pharmaceutical industry into the newly emerging biopharmaceutical industry. This new industry is a combination of traditional pharmaceutical firms, like Merck or Pfizer, and new biotechnology

Table 1. Descriptive statistics and bivariate correlation matrix

	Mean	S.D.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. New Product Development	12.34	8.30															
2. Firm Performance	21.49	12.08	0.49														
3. Total SAs	27.78	16.65	0.71	0.60													
4. (Total SAs)^2	1040.47	1175.97	0.65	0.46	0.95												
5. Exploration SAs	9.91	7.64	0.65	0.51	0.93	0.92											
6. (Exploration SAs)^2	154.72	234.17	0.60	0.31	0.84	0.94	0.93										
7. Exploitation SAs	18.41	9.81	0.63	0.67	0.90	0.77	0.73	0.56									
8. (Exploitation SAs)^2	432.03	390.47	0.54	0.67	0.87	0.78	0.70	0.56	0.97								
9. Age Total SAs	38.65	19.10	–0.31	–0.03	–0.35	–0.32	–0.31	–0.28	–0.30	–0.26							
10. Age Exploration SAs	46.24	42.38	–0.06	–0.19	–0.11	–0.12	–0.10	–0.09	–0.10	–0.13	0.05						
11. Age Exploitation SAs	46.76	22.50	–0.38	–0.19	–0.40	–0.32	–0.36	–0.27	–0.40	–0.34	0.88	–0.04					
12. Equity vs. Non-Equity SAs	0.13	0.20	–0.16	–0.22	–0.18	–0.13	–0.06	–0.07	–0.25	–0.18	0.05	0.13	–0.09				
13. Size	3.48	1.09	0.17	0.31	0.34	0.32	0.32	0.28	0.32	0.31	–0.10	0.01	–0.02	–0.44			
14. Lagged Firm Performance	21.71	29.12	0.14	0.54	0.24	0.19	0.30	0.18	0.16	0.19	–0.02	–0.09	–0.05	–0.12	0.41		
15. Economies of Scope	21.31	10.99	0.46	0.25	0.53	0.51	0.63	0.56	0.36	0.34	0.07	–0.26	0.09	–0.17	0.27	0.07	
16. Country	0.50	0.50	0.07	0.39	0.19	0.07	0.13	0.02	0.30	0.26	0.13	–0.08	–0.03	–0.15	0.36	0.12	0.17

Correlations greater than or equal to 0.35 are significant ($p < 0.05$), $N = 32$.

Table 2. Regression results:

Dependent variable: New Product Development				
Independent variables	Model 1 (base)	Model 2	Model 3	Model 4
Intercept	1.9272***	1.4890**	2.2317***	0.4256
	(0.4258)	(0.5448)	(0.5039)	(0.6104)
Equity vs. Nonequity SAs	–0.7329	–0.4558	–0.6050	0.4304
	(0.7395)	(0.5865)	(0.6015)	(0.5949)
Size	0.0133	–0.0585	–0.0730	0.0252
	(0.1070)	(0.0917)	(0.0924)	(0.0772)
Economies of Scope	0.0264*	0.0066	0.0152	0.0150
	(0.0106)	(0.0102)	(0.0121)	(0.0095)
Country	–0.0496	–0.1345	–0.0940	–0.2240
	(0.2389)	(0.2138)	(0.1963)	(0.1616)
Age Total SAs		–0.0051		
		(0.0061)		
Age Exploration SAs			0.0006	–0.0015
			(0.0021)	(0.0018)
Age Exploitation SAs			–0.0112*	–0.0087†
			(0.0056)	(0.0048)
Total SAs		0.0667***		
		(0.0198)		
(Total SAs)^2		–0.0006*		
		(0.0002)		
Exploration SAs			0.0060	–0.0307
			(0.0210)	(0.0386)
(Exploration SAs)^2				0.0008
				(0.0009)
Exploitation SAs			0.0345*	0.2176***
			(0.0147)	(0.0470)
(Exploitation SAs)^2				–0.0042***
				(0.0010)
Likelihood ratio test	96.85***	116.02***	115.31***	129.42***
Improvement over base		19.18**	18.46*	32.57***
LR index (pseudo R^2)	0.31	0.38	0.37	0.42

Standard errors in parentheses; $^{\dagger}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$
Models are negative binomial count using a maximum likelihood estimation procedure.

firms, such as Biogen or Immunex. This transformation through combination is the result of corporate entrepreneurship efforts by incumbent pharmaceutical firms. It has mainly been accomplished through strategic alliances with new biotechnology entrants (Greis, Dibner, and Bean, 1995). In turn, the biotechnology start-ups have utilized extensive cooperation with incumbents to commercialize biotechnology (Shan *et al.*, 1994). The cooperation of Genentech and Eli Lilly is a case in point, as Genentech has preferred to license its human insulin based on recombinant DNA (Humulin) to Eli Lilly instead of commercializing it on its own (Lee and Burrill, 1994).

Incumbents may survive radical technological change through strategic alliances established prior to a discontinuity (Mitchell and Singh, 1996) or by utilizing complementary assets (Tripsas, 1997). This research links interfirm cooperation, as a mechanism for incumbents to exploit complementary assets, and new product development to firm performance in the post-discontinuity time period. I show that an incumbent firm's corporate entrepreneurship strategies, in this case pursuing strategic alliances with new entrants as a response to radical technological change, led to improved new product development and superior performance.

Prior research has shown that there exists a curvilinear relationship between a start-up's stra-

Table 3. Regression results

Dependent variable: Firm Performance		
Independent variables	Model 5 (base)	Model 6
Intercept	9.5767*	7.4696†
	(4.0248)	(3.9406)
Lagged Firm Performance	0.2046**	0.1907**
	(0.0597)	(0.0569)
Economies of Scope	0.1811	0.0224
	(0.1594)	(0.1691)
Country	7.2145*	7.4210*
	(3.4679)	(3.2819)
New Product Development		0.4615*
		(0.2227)
F-Statistic	7.02**	6.97***
Adjusted R^2	0.37	0.44
Improvement over Base (ΔR^2)		0.07*

Standard errors in parentheses.
†$p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$
Models are OLS.

tegic alliances and its new product development (Deeds and Hill, 1996). This study, however, demonstrated a curvilinear relationship between an incumbent's strategic alliances with new entrants and the incumbent's new product development. The focus on the incumbent, rather than the start-up, is novel. Therefore, this research contributes to the limited body of knowledge regarding the success of incumbents facing radical, technological change (cf. Christensen and Bower, 1996) and is one of the first studies to examine strategic alliances as a mechanism for incumbents to access and commercialize a radically new technology.

I am also able to show that incumbents that focus on exploitation rather than on exploration alliances will experience a competitive advantage, at least in the short term. This indicates that alliances in the biopharmaceutical industry seem to be driven by a search for mutually complementary assets. This finding is consistent with Shan and Hamilton (1991), who find that complementary assets are determinants of the formation of cross-border alliances in biotechnology. On the other hand, less radical technological change would probably limit the effectiveness of exploitation alliances and increase the effectiveness of exploration alliances. In such a situation, I would expect an incumbent firm to focus more on exploration alliances, assuming the incumbent firm is not in a position to develop the technology alone. Should the incumbent be in a position to commercialize the new technology alone, there would be no need for cooperation between new entrants and incumbents (Williamson, 1985).

I also find that an incumbent's new product development is positively associated with its performance in the post-discontinuity time period. It has been pointed out that new product development is critical for the success of entrepreneurial start-ups (Schoonhoven, Eisenhardt, and Lyman, 1990; Deeds, DeCarolis, and Coombs, 2000). It seems that incumbents that are able to speed innovative products to the market will be rewarded with superior performance.

A limitation of this study is its focus on surviving alliances. In particular, exploration alliances are likely to have a higher mortality rate than exploitation alliances. However, alliances in the biopharmaceutical industry are characterized by longevity because the product development process often requires 15 years or more (Burrill, 1999). Shan *et al.* (1994) found that only 15 percent of the alliances entered since the early 1970s has expired by 1989. Thus, our results are unlikely to be materially affected by a potential survivorship bias.

I present evidence indicating that corporate entrepreneurship by incumbent firms may lead to wealth creation. By the late 1990s, the incumbent pharmaceutical firms marketed seven out of the top-10 selling biotech drugs, even though none of the drugs was developed by them. Those seven drugs accounted for two thirds of the revenues of the top-10 selling biotechnology drugs (Morrison and Giovannetti, 1998). Overall revenues of new biotechnology drugs were $22 billion in 1999, about 15 percent of total revenues in pharmaceuticals (Burrill, 1999).

I was also able to obtain data for firm-specific cooperative arrangements stipulating the revenue partition among the developer of the product, the new biotechnology firm, and the marketer of the product, the incumbent pharmaceutical firm. In 1998, for example, the biotechnology company Immunex introduced Enbrel, a radical new treatment for rheumatoid arthritis based on a genetically engineered human protein. The annual sales of Enbrel are forecast to be $5 billion by 2005. American Home Products, whose sales force co-

promotes Enbrel, receives about 45 percent of the gross profits. Another example is the cooperation between Eli Lilly and the biotechnology firm Icos to commercialize a drug for the treatment of male and female sexual dysfunction, which is expected to be a direct competitor for Pfizer's Viagra. The revenue partition will be 50/50 between Lilly and Icos. Such favorable revenue partition for incumbents is explained by the fact that incumbent pharmaceutical companies enjoy a tremendous advantage in FDA regulatory management and drug distribution. Large pharmaceutical companies have sales forces that approach or exceed 10,000 people. A standard time horizon of more than 10 years and a cost of up to $500 million for drug development in combination with the incumbent's advantage in drug approval and distribution explains why fully integrated new biotechnology firms like Amgen are the exception, rather than the rule.

In addition, prior research has shown that strategic alliances with existing pharmaceutical companies bestowed legitimacy on new biotechnology firms, which in turn had positive effects on their stock valuations (Stuart *et al.*, 1999). Thus, one could speculate that incumbents have not only created wealth for themselves, but also enhanced the rents available to start-ups. On the other hand, one could argue that incumbents co-opted the new entrants via interfirm cooperation (Hoang, 1997), and that this contributed to the suspension of the process of creative destruction. This debate provides an avenue for future research.

The results of this paper also have implications for strategic management. In the context of radical technological change, a firm's competitive advantage may lie in its network-level strategy (Mitchell and Singh, 1996). For example, managers of incumbent firms in industries experiencing a technological discontinuity should gain an initial competitive advantage by searching out those strategic alliance partners that allow the incumbent firm to exploit its assets that have retained their value in the new environment (Niederkofler, 1991). This strategy should also enable incumbent firms to buy time in order to build the new technological competencies required for competition in the new environment.

Future research should attempt to test the theory advanced in this paper in different industry settings to enhance its external validity. In addition, more work remains to be done to understand the impact of different types of alliances on firm performance. Finally, interfirm networks are dynamic, and so we need to better understand how the effectiveness of different types of alliances changes over time.

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