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THE ROLE OF STRATEGIC ALLIANCES IN HIGH-TECHNOLOGY NEW PRODUCT DEVELOPMENT

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The authors examined 905 new product innovations introduced since September 1988 to determine the influences on product innovativeness, with a specific interest in strategic alliances, or cooperative strategies. Findings suggest that single firms, horizontal cooperative strategies, small and mixed-sized firms, biochemical industries, cross-industry product offerings, cross-industry cooperations, the progression of time, and European firms tend to indicate significantly more innovative products. Implications are proposed for business practitioners and researchers with specific application to the diffusion of innovation.

Innovative decision processes have been the subject of extensive theorizing, modeling, and empirical testing (D'Aveni, 1994; Dickson, 1992; Gatignon and Robertson, 1991; Hirschman, 1980; Rogers, 1962). While researchers in marketing have focused on the adoption and diffusion of innovation along with similar behavioral constructs, the economics and management literature have presented a rich exploration of product innovativeness (Acs and Audretsch, 1988; Ettlie and Rubenstein, 1987; Mahajan, Muller, and Bass, 1990; Myers and Marquis, 1969; Scherer, 1980; Utterback, 1974). Additionally affecting this research stream, strategic alliances, or new cooperative organization forms, are replacing simple market-based transactions and traditional bureaucratic hierarchical organizations (Harrigan, 1988; Nielsen, 1988; Webster, 1992). However, the role that this new organizational arrangement has on product innovativeness is left unexplored. Global and increasingly key organizational forms are being created through cooperative ventures (Perlmutter and Heenan, 1986; Terpstra and Simonin, 1993). This article seeks to further innovation research with an exploration of product innovativeness within the context of cooperative strategies and hypercompetition.

Gold (1981) observed that changes in the diffusion rates 'may be due in large measure to the extent of technological changes in the innovations being studied rather than changes in the receptiveness of perspective adopters'. Though a market economy relies on this dynamic technical advancement of products, the competitive environment and marketing strategy are ignored by the dominant diffusion of innovation paradigm (Gatignon and Robertson, 1991). Additionally, examining the inherent innovativeness of the product manifests different implications than the traditional behavioral innovation adoption model.

Different levels of innovation (degree and rate) have been explored along with product, industry, and firm-specific variables but never all in concert (Buckley and Casson, 1988; Ettlie and Rubenstein, 1987; Robertson, 1967). Consequently, there has been a clear gap in understand-

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ing how technological change affects organizational decisions to utilize cooperative strategies, especially with regard to competitive pressure over time. With the increasing use of cooperative arrangements between competing firms and the convergence of many high-technology fields, a broad longitudinal investigation is needed to provide insight into the innovativeness of new products by examining the attributes of the firm, the firm's new products, and the circumstances in which the products are introduced. Further, dynamics of the marketplace are crucial to strategic theory (Porter, 1990).

In recent years, dynamic models of competition, such as theory of competitive rationality (Dickson, 1992) and theory of hypercompetition (D'Aveni, 1994), have begun to emerge with emphasis on competitive urgency as a result of rapid technological change and competitive pressure. These models share in common similar origins of the Schumpeterian economics emphasizing the role of innovation (Schumpeter, 1939). We begin by reviewing prior research in management, marketing, and economics on innovation. Drawing from recent dynamic models of competition, research hypotheses are developed and subsequently tested. We conclude with a discussion of the relevant research findings and alert managers to the important implications of pursuing particular strategies to increase product innovativeness.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

While there has been a long history of inquiry into the degree of product innovativeness (Schumpeter, 1939; Barnett, 1953), one of the greatest obstacles to understanding innovation has been the lack of meaningful measures (Capon *et al.*, 1992; Gatignon and Robertson, 1991; Kuznets, 1962; Utterback, 1987). Popular proxy measures of innovation have involved R&D and patents but both have been criticized as biased. In addition, they engender problems that affect both within-industry and between-industry comparisons (Griliches, 1990). In a scheme that has come to dominate diffusion research, Rogers (1962) described innovation as an idea that was perceived as new by the individual. One framework that has been suggested classifies innovation by its effect on established patterns: continuous, discontinuous, and dynamically discontinuous (Robertson, 1967). The extent to which the new product changes the customer's habits or usage patterns would indicate the degree of product innovativeness. While we would prefer to capture the consumer's perceptions of product 'newness', perceptual variation confounds measuring the consumers' roles as innovators and the causes of an individual's innovativeness preference remain obscure (Hirschman, 1980).

Extant literature suggests that innovativeness be investigated from a perspective of inherent product attributes through three schemata: 'newness to the market', 'newness to the firm', or a combination thereof. First, a 'newness to the market' framework for classifying innovations by their effect on established usage patterns was originally developed by Robertson (1967) and has been widely used along with its tripartite variants (e.g., Drucker, 1991; Kotabe, 1990; Leroy, 1976). Similarly, other studies sought to differentiate the types of innovation by how drastically the product was changed: either evolutionary vs. revolutionary innovation (Utterback, 1987) or radical vs. incremental innovation (Ettlie, Bridges, and O'Keefe, 1984). Thus, product innovations can be defined as either continuous, dynamically continuous, or discontinuous. Each category is clearly distinct and all three types of innovations can be the result of programmatic development (Drucker, 1985).

In the second schema, a 'newness to the firm' framework is typically made up of three levels: (1) minor change of previous product; (2) major change of previous product; and (3) totally new to the firm. This firm-based framework has not been used independently as it fails to reflect a product's impact on either competitors or consumers. But from a broader perspective, the measure captures the ability of the firm to service and continue to update the technology which are key consumer concerns.

In the third schema, Booz, Allen & Hamilton, Inc. (1982) combined 'newness to the market' and 'newness to the firm' frameworks into a six-level scale to reflect a dynamic interaction between the firm and the marketplace. The six levels of product innovativeness include: (1) *cost reductions*—new products that provide

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similar performance at lower cost; (2) *repositionings*—new products that are targeted at new markets or new market segments; (3) *improvements in/revisions to existing products*—new products that provide improved performance or greater perceived value and replace existing products; (4) *additions to existing product lines*—new products that supplement a firm's established product lines; (5) *new product line*—new products that allow a firm to enter an established market for the first time; and (6) *new-to-the-world product*—new products that create an entirely new market. While all these product development and introduction options have been implemented, there has been no empirical research suggesting that one option results in, or results from, increased product innovativeness.

In this study three dimensions of product innovativeness will be developed based on the previously discussed measures of innovativeness: (1) newness to the market; (2) newness to the firm; and (3) Booz, Allen, & Hamilton's innovativeness scale. Additionally, from a review of the literature, a conceptual model (Figure 1) and eight hypotheses are developed concerning the effect that the number of firms involved, nature of the strategic linkages, firm size, industry, temporal order, and nationality have on a product's degree of innovativeness.

Hypotheses

Number of firms/cooperative strategies

In industries experiencing rapid technological change, a single company rarely has the full range of expertise needed to offer timely and cost-effective new product innovations (Teece, 1987). In fact, a turbulent, uncertain environment serves to increase the motivation to cooperate and innovate (Buckley and Casson, 1988; Dickson, 1992; Lengnick-Hall, 1992). Alternatively, it is difficult to attract willing partners because revolutionary innovations and cooperative ventures are fragile, vexatious to manage, and often fail (Spekman and Salmond, 1992). Despite these problems, strategies to reduce enormous development costs, lessen inherent risks of product introduction, and access technology/know-how unavailable internally have led firms to shift to strategic alliances or cooperative ventures (Hamel, Doz, and Prahalad, 1989; Kogut, 1988; Ohmae, 1989; Webster, 1992). The theoretical basis for this lies in interorganizational exchange behavior in which, given functional specialization and a scarcity of resources, organizations exchange resources for mutual benefit (Bucklin and Sengupta, 1993; Frazier, 1983). This view complements the clear resource and institutional constraints on a firm's behavior and motives of interfirm technology cooperation inherent in dynamic models of competition (Hagedoorn, 1993).

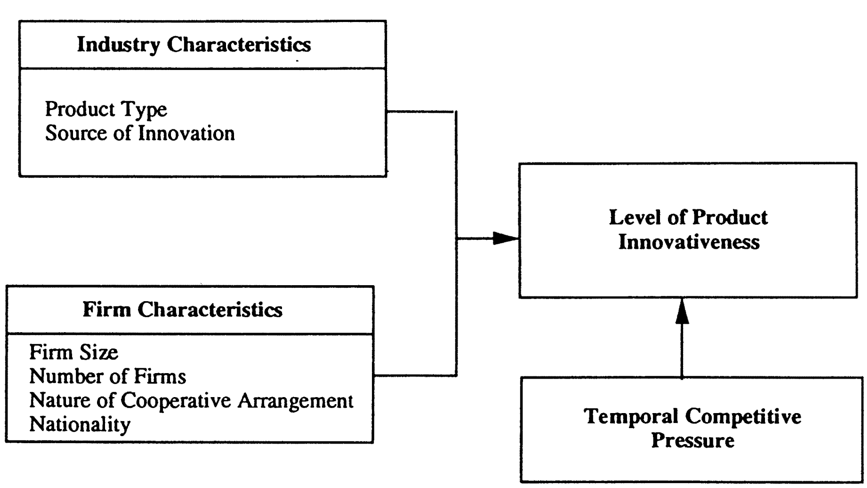

Figure 1. Industry, firm, and temporal factors influencing the level of product innovation

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Additionally, interorganizational linkages may help firms cope with problems faced at different stages of industry evolution (Roberts and Berry, 1985) or span boundaries which are positively associated with organizational innovativeness (Kimberly, 1978). A natural aperture through which cooperation could progress is across product development, manufacturing, and marketing (Ouchi, 1980). New product development increasingly requires the integration of R&D, marketing, engineering, and design (Kotabe, 1992; Kotler and Rath, 1984). Interdisciplinary development increases the complexity of introducing the new product while corporate limitations require focusing on internal resources (Prahalad and Hamel, 1990). Thus, firms need to source some knowledge and technology externally in order to concentrate on its competitive advantage (Teece, 1987; Ohmae, 1989). Successful firms employ their resources to focus on their relative competitive advantage and then leverage the skills and knowledge outside the firm to maximize this advantage (Dickson, 1992). Cooperating firms' cumulative resources, complementary skills, and boundary-spanning activities are likely to increase the level of innovativeness of products. Therefore:

Hypothesis 1: Products of cooperating firms tend to be more innovative than products of a single firm.

Strategic linkage

Vertical linkages occur when firms cooperate across different levels of the value-added chain whereas horizontal linkages are across the same level. Vertical linkages are distribution or outsourcing arrangements, while common horizontal linkages would include R&D consortia, patent swaps, technology transfers, and joint ventures which would be more likely to supplement the internal technology base. Hagedoorn (1993) estimates that R&D joint ventures and research cooperations, along with joint R&D agreements and equity investments, are over 85 percent motivated to improve the long-term technological prospect of the product market combinations of the companies. On the other hand, only a small portion of vertical linkages such as customer–supplier relationships and distribution agreement are designed for such a purpose. Thus, horizontal linkages are more likely to be strategically motivated to improve long-term product technology development, while vertical linkages tend to be more concerned with cost economizing rather than with product innovation. Through similar logic of external linkages, single firms are considered an internal vertical linkage (Williamson, 1979).

Additionally, interdepartmental conflict erects barriers to innovation through differences in time horizons, communication depth, and contact infrequency (Roussel, Saad, and Erickson, 1991). While horizontal cooperation would help eliminate or reduce the cultural and technical barriers, barriers to innovation within the firm would be unlikely to change in a vertical cooperation between firms. In fact, physical distance between cooperating firms could decrease the level of contact, therefore requiring each communication to be all the more important and giving horizontal linkages a decided advantage. Also, a firm makes better use of outside resources if it has its own general expertise. A broad internal technology base allows the firm to be more efficient in acquiring and implementing new core complementary knowledge (Granstrand and Sjolander, 1990; Hamel *et al.*, 1989) over the benefits of seeking new peripheral knowledge from a vertical linkage. Therefore:

Hypothesis 2: The products of cooperating firms using a horizontal linkage tend to be more innovative than products introduced using a vertical linkage between cooperating firms.

Firm size

Ambiguity as to the role of firm size in innovativeness is still evident (Acs and Audretsch, 1988; Ettlie and Rubenstein, 1987; Scherer, 1980). Large firms have a stable of products that could be extended through continuous improvements. Also, large firms may be more efficient innovators because of larger, more diverse resources and skills, better developed marketing channels, and economies of scale (Baldwin and Scott, 1987). On the other hand, small companies must be highly innovative to attract attention, interest investment, and more importantly overcome larger competitors' advantages to attract customers (Utterback and Abernathy, 1975). These smaller, less integrated, and

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underfunded companies with new technological innovations cooperate with established companies to gain access to the latter's complementary assets of reputation and distribution channels, customer bases, and possible acceptance as dominant design in subcategory markets. It is wholly conceivable that products successfully introduced by large firms are the result of small firms' innovations (Granstrand and Sjolander, 1990), since large firms are in a better position to learn and imitate with manufacturing and distribution advantages over a small innovator (Miles and Snow, 1978). Thus, size may also play a role in that diversity of firm size, a mixture of large and small firms, was supported as most conducive to innovation (Scherer, 1980). So, in the Schumpeterian tradition of the dynamic models of competition, small firms normally need dynamically continuous or discontinuous innovations to break into the market and to sustain competitive lead. Therefore:

> *Hypothesis 3: The product of a small firm tends to be more innovative than a product introduced by a large firm.*

Industry effect

At the heart of new technologies is a diverse range of basic and applied research requirements and sectoral convergence or 'technology fusion' (Hagedoorn, 1993; Kodama, 1992). Kodama (1992), for example, differentitaes between two types of technology fusion. The first type is identified as mechatronics or Type M products. Type M products are essentially assembled from mechanical and electronic components. Second, biotechnology, pharmaceutical, and chemical, or Type B, products are the result of genetic engineering and biochemistry. Type B products are created at the molecular level and are inseparable from their process. Hagedoorn (1993), focusing on the industry level, empirically affirms the differences between industries' innovativeness due to convergent technologies.

Contrary to the studies of Myers and Marquis (1969) and Utterback (1974), which did not find significant differences between industries, reverse engineering and inventing around are technically easier with type M products (e.g., microelectronics) than with the Type B products (e.g., pharmaceuticals). Furthermore, these studies did not have a similar industry segment as in our study and, more importantly, environmental and technological changes have transformed whole industries in response to the demands of hypercompetition (D'Aveni, 1994). A single or group of industries' level and rate of innovativeness may become more pronounced during a period because of technological, structural, and competitive characteristics having a differential effect. Also, for those Type B products, not only the product *per se* but also inventive processes are protected by patent, making it more difficult to imitate (Levin *et al.*, 1987). Given the nature of these products and the relative difficulty of reverse engineering and inventing around, Type B products tend to be more innovative than Type M products in order to break into the market.

> *Hypothesis 4a: The products introduced in Type B industries tend to be more innovative than products introduced in Type M industries.*

Calantone, Di Benedetto, and Meloche (1988) found that successful product innovations frequently were revolutionary and originating from outside the industry. A discontinuous change in a product from outside the industry requires firms to update old technology or gain access to new technology through external acquisition (Cooper and Schendel, 1976). This suggests that it may be necessary for firms to partner with other firms to complement each other's strengths and weaknesses—small with large firms and interindustry cooperations—although the dynamic models of competition suggest that cooperation might be temporary.

While incremental innovations often originate from inside the firm and are derived largely from the experience of people within the firm (Czinkota and Kotabe, 1990; Dickson, 1992; Utterback, 1987), a major innovation is often viewed as disruptive to established investments (D'Aveni, 1994). A major change would affect the goals and the control systems which are the bases for authority, leaving change often without a constituency (Tushman and Anderson, 1986). Incremental innovation often reinforces the existing structure. This bias of an industry toward conservatism and incremental change offers opportunities for invasions of the existing market by substitute products from firms outside the

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industry (Abernathy and Clark, 1985; Porter, 1980). The convergence of technology and industries creates enormous cross-industry innovation subsidies. Therefore, firms associated with an industry outside an existing product's industry are likely to offer more innovative products than firms within the industry (Kodama, 1992).

Hypothesis 4b: Products introduced by firms associated with an industry outside an existing product's industry tend to be more innovative than products introduced by firms associated with the product's industry.

Hypothesis 4c: The products introduced by firms that are cooperating across industries tend to be more innovative than products introduced by firms that are cooperating within the same industry.

Temporal aspects

Time (i.e., competitive imitation, intensification of competition, and knowledge accumulation) renders nearly all advantages obsolete (Fardoust and Dhareshwar, 1990; Stalk, 1988). Since new products determine many firms' competitive strengths (Booz, Allen & Hamilton, 1982), there are considerable pressures to innovate as a result of the shortened product life cycle, rapid price reduction, and eroding profit margins. Firms must improve their speed and chance of introducing successful innovations (Davidson and Harrigan, 1977; Hagedoorn, 1993). This accelerated technological environment further demands a more significant innovation and a faster implementation for a firm to stay ahead of competition than in the past (D'Aveni, 1994; Dickson, 1992). As a result, increasingly innovative products are introduced in a shorter time interval.

Hypothesis 5: Product innovativeness tends to increase with time.

Nationality

Growth and profits come largely from new products (Booz, Allen & Hamilton, 1982). Additionally, there has been a renewed interest in manufacturing process innovation, which was long ignored in traditional considerations of strategy development as a competitive weapon (Cohen and Zysman, 1987). While firms of the Triad place emphasis on manufacturing and concomitant product quality (Kotabe, 1990; Utterback, 1987), different innovation biases and technology demands exist between firms of different national origin (Franko, 1976; Pavitt, 1969). Though comparative marketing studies have shown that different marketing strategies can be associated with countries (Boddewyn, 1981; Kotabe and Duhan, 1991), it has not been determined how cross-national cooperations affect innovation.

Increasingly, global products are becoming standardized and world dominant designs are being sought by both firms and customers (Kotabe, 1990). Convergence of high-technology fields, degree of expertise needed, and pace of knowledge also push firms to cooperate (Ohmae, 1989). Porter (1990) argues, however, that despite the globalization of competition and urgency of technology acquisition, the sustainability of firms' competitive advantage depends strongly on national characteristics of competitive rivalry, supporting industries, demand conditions, and productive factor availability in their home country. While the dynamic models of competition do not directly address national differences in innovativeness, they do state that structural and transactional disequilibrium in markets to be addressed by multinational firms.

An important factor in the endurance of a global alliance is compatibility between partners with a common set of values, style, and culture (Perlmutter and Heenan, 1986). All elements of the organization, including competitive rationality, are potentially constrained by the cultural environment (Farmer and Richman, 1965; Terpstra and David, 1991). Many U.S. managers still regard cooperation with skepticism and suspicion while the Japanese and Europeans are more culturally familiar to shared enterprises (Perlmutter and Heenan, 1986). In addition, all firms would rather have a partner of their own nationality (Montgomery, 1993). Cultural incompatibility and lack of trust can produce enormous difficulties. As a result, many 'alliances' between U.S. companies and their Asian or European counterparts tend to be little more than sophisticated outsourcing arrangements (Hamel *et al.*, 1989). Therefore, new products introduced by single firms or cooperating firms from the

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same country are likely to be more innovative than those introduced by cross-nationally cooperating firms.

Hypothesis 6: Products introduced by firms of the same Triad region tend to be more innovative than products introduced by cross-nationally cooperating firms.

In the following sections, the methodology for collecting the data and conducting the analysis is presented. This is followed by a discussion of the results, from which conclusions and recommendations are drawn.

CONTENT ANALYSIS

Technique and considerations

Major innovations come to fruition over a span of years; so cross-sectional and survey data do not adequately capture how innovation occurs (Utterback, 1979). Longitudinal research adds considerable insight and permits the researcher to determine underlying temporal linkages between competitive environment, organizational and industry characteristics, and innovativeness. Our data base consists of 905 new product introductions in the United States by firms from the Triad regions (the United States, Western European countries, and Japan) announced in the *Wall Street Journal* over a 5-year period (since the *inception* of the 'Technology' section in September 1988). Because of the prevalence of 'vapor ware' (i.e., proactive announcements of nonappearing products meant to disrupt sales of competitors), only products that have been or were to be introduced within 1 month were included in the study. Care was taken not to double count products. Finally, software was excluded from the study because of infrequent and relatively incomplete coverage of the category.

Each article was examined using the 'content analysis' technique—the objective, systematic, and quantitative description of the manifest content of communication (Berelson, 1954). Content analysis is used in a variety of disciplines and has been applied, for example, to analyze the sources of satisfaction and dissatisfaction in service encounters (Bitner, Booms, and Tetreault, 1990) and retail store image (Zimmer and Golden, 1988), as well as international partnerships (Porter and Fuller, 1986; Terpstra and Simonin, 1993).

A reliable and objective analysis requires that the experiment be replicable and systematic, and that categorizations be according to consistently applied rules to avoid researcher bias (Holsti, 1968). Content analysis has the same advantages and disadvantages of other inductive procedures such as factor analysis, cluster analysis, and multidimensional scaling (Hunt, 1983). The product's effect on established usage patterns and inherent product competitive advantages, namely the degree of innovativeness, is well suited to content analysis and can supply external validity to the results (Kolbe and Burnett, 1991).

Sample and classification of product introductions

After an initial agreement on concepts and their operational definitions, three judges independently completed the coding instrument for the product introduction articles. Interjudge agreement (based on the average of a three independent judge group consisting of a technology researcher with a PhD degree, a product designer with an MBA degree, and a product engineer with a graduate engineering degree) was 92 percent, which compares favorably with past interjudge reliability of 60–97 percent (Zimmer and Golden, 1988; Kolbe and Burnett, 1991). Thus, there were few differences in the placement of the articles in the categories. In total, 905 product introduction articles remained after contentious articles were jointly evaluated to obtain unanimous agreement in categorization. In the next section, we analyze the data and discuss the results. Then, implications and future research directions are suggested.

MEASURES

Initially, Robertson's (1967) tripartite 'Newness to the market', the three-part 'Newness to the firm', and Booz, Allen & Hamilton's (1982) six-part 'Level of innovation' were individually employed as dependent variables; all three models were found to be significant ($p < 0.0001$) with consistent results. Since the three items of innovativeness were highly correlated and in an effort to capture as many dimensions and

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interactions as possible, they were combined to increase measurement reliability, as follows: as the first two items were measured on a three-point scale and the third item was on a six-point scale, these items were respectively standardized to have a mean of 0 and a standard deviation of 1, and the mean of the three standardized items were computed to represent 'product innovativeness' (INNOV: Cronbach alpha = 0.82). Excluding any of the three items of innovativeness served to reduce the alpha coefficient. The independent variables were the number of firms that were involved in the product introduction (NO_FIRM), strategic linkage between cooperating firms (LINKAGE: vertical vs. horizontal),[1] size of the firm (SIZE: large = *Fortune* 500 or *Fortune International* 500, small = otherwise, and mixed = at least one in each firm size category), product type (PRODUCT: Type B vs. Type M), agreement between the firm's industry and the product's industry (MATCH), month in which the product was introduced (DATE: i.e., September 1988 = 1, with an increment of 1 per month onward), and nationality of the firm (NATION).

There were too few cases of three or more cooperative firms introducing a product, so the NO_FIRM variable for the number of firms introducing a product was collapsed into two categories: (1) cases of a single firm offering a new product; and (2) cases of multiple firms offering a new product. For the NATION variable, European–Japanese cooperations and U.S.–European–Japanese cooperations categories were deleted as there were too few cases. Thus, the NATION categories analyzed were (1) European, (2) Japanese, (3) U.S., and (4) cross-national (U.S. with one or more foreign partners).

Because of the longitudinal nature of this study,[2] the whole data set is analyzed as well as the split of the data set to uncover any trends. This split-half analysis allowed us to ascertain that the stability of the results was very high across phases and time frames. In conducting this comparison, we offer a measure of internal validity. While internal validity does not strictly allow us to extend or generalize our findings, it may suggest venues for future research.

ANALYSIS

The study was accomplished in two phases. Phase 1 includes all product introductions and is designed to examine the difference between product innovativeness of (a) single vs. multiple cooperating firms and (b) horizontal vs. vertical linkages. Phase 2 includes only product introductions by cooperating firms. The results of the ANCOVA are shown in Table 1.

Phase 1

The number of firms involved in the product introduction turned out to be significant ($p < 0.05$) for the first period, for the second period ($p < 0.10$), and subsequently for the aggregate period ($p < 0.05$), although in the opposite direction than hypothesized in Hypothesis 1. There appears to be a disadvantage to cooperating with other firms in developing and introducing more innovative new products. Cooperating firms seeking to reduce the risk inherent in the more innovative products, sharing in the development and introduction costs, or pooling resources for other benefits, may be penalizing their innovative activities. We cannot rule out the possibility that poor performance can cause firms to seek additional cooperation with competitors (Burgers, Hill, and Kim, 1993). Our data base fails to lend support for Hypothesis 1. This point will be discussed further under 'Conclusions and implications'.

The strategic linkages were classified into two categories: vertical cooperations (links were not between similar functions, i.e. distribution

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[1] Single-firm cases are essentially a form of vertical cooperation within the company and are thus considered vertical in terms of LINKAGE.

[2] We examined a potential heteroskedasticity problem in our longitudinal data. Based on residuals plotted against the predicted values of the level of product innovativeness, no significant heteroskedasticity was detected. Further, we examined the potential impact of outliers that might exist in our data set. Based on residual and Cook's D statistic criteria (Cook, 1979), about 5 percent, or 45 cases out of the sample of 905 cases, exceeded the Studentized residual criterion, although Cook's D statistic criterion suggested that their impact was negligible. Subsequently, analyses were performed both on the full sample and on the reduced sample (without those 45 cases). The difference observed in the reduced-sample results was a slightly improved R^2 by about 2 percent across the board, without any measurable change in the estimated coefficients and their statistical significance. For these reasons, heteroskedasticity and outliers do not appear to cause any undue strain on the estimated parameters.

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Table 1. Industry, firm, and temporal factors influencing the level of product innovation

	Expected sign	1988–89 Coefficient estimate		1990–92 Coefficient estimate		Aggregate Coefficient estimate	
		Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
Intercept		−0.28	−0.67[a]	−1.35[a]	−1.50[a]	−0.62[a]	−0.86[a]
		(−1.42)	(−3.52)	(−5.98)	(−6.19)	(−5.31)	(−6.99)
H1: NO-FIRM							
Multiple	(+)	−0.29[b]		−0.21[c]		−0.19[b]	
		(−2.28)		(−1.75)		(−2.21)	
Single		–		–		–	
H2: LINKAGE							
Horizontal	(+)	0.31[b]	0.23[c]	0.32[a]	0.23[b]	0.35[a]	0.29[a]
		(2.17)	(1.68)	(2.62)	(2.14)	(3.77)	(3.34)
Vertical		–	–	–	–	–	–
H3: SIZE							
Small	(+)	0.52[a]	0.55[a]	0.45[a]	0.48[a]	0.49[a]	0.51[a]
		(5.58)	(5.86)	(4.92)	(5.19)	(7.37)	(7.72)
Mixed		0.11	0.05	0.27[b]	0.23[b]	0.17[c]	0.14
		(0.77)	(0.35)	(2.26)	(1.93)	(1.83)	(1.59)
Large		–	–	–	–	–	–
H4a: INDUSTRY							
Type-B	(+)	0.32[a]	0.34[a]	0.30[a]	0.31[a]	0.37[a]	0.38[a]
		(3.32)	(3.49)	(3.25)	(3.28)	(5.46)	(5.56)
Type-M		–	–	–	–	–	–
H4b: MATCH							
Industry ≠ Product	(+)	0.16[c]	0.13	0.14[c]	0.14	0.17[a]	0.15[b]
		(1.65)	(1.32)	(1.63)	(1.53)	(2.56)	(2.29)
Industry = Product		–	–	–	–	–	–
H4c: COOP							
Interindustry	(+)		0.30[b]		0.10		0.18[b]
			(2.27)		(0.84)		(2.03)
Intraindustry			–		–		–
H5: DATE	(+)	−0.007	0.006	0.02[a]	0.02[a]	0.01[b]	0.01[a]
		(−1.41)	(−1.21)	(6.10)	(5.89)	(4.77)	(4.73)
H6: NATION							
Europe	(+)	0.75[a]	0.84[a]	0.01	0.10	0.32[c]	0.38[b]
		(2.57)	(2.97)	(0.06)	(0.48)	(1.85)	(2.26)
Japan	(+)	0.12	0.20	0.02	0.11	0.07	0.14
		(0.60)	(1.06)	(0.09)	(0.61)	(0.52)	(1.04)
U.S.A.	(+)	0.13	0.17	−0.02	0.04	0.09	0.13
		(0.92)	(1.30)	(−0.15)	(0.36)	(1.00)	(1.45)
Cross-national		–	–	–	–	–	–
	n	440	139	465	168	905	307
	R^2	0.16[a]	0.16[a]	0.16[a]	0.16[a]	0.13[a]	0.13[a]

[a] $p < 0.01$; [b] $p < 0.05$; [c] $p < 0.10$.

Note: Corresponding t-statistics are shown in parentheses.

Interpretation: The level of product innovativeness was measured as a standardized Z score with a mean of 0 and a standard deviation of 1. The actual level of product innovativeness observed in the data set varied from −1.74 to 2.19, with a total range of 3.93 standard deviations. Therefore, the estimated coefficients are expressed in standard deviation units.

For example, in the aggregate model, a coefficient for NO_FIRM suggests that the level of innovativeness of products introduced by cooperating firms is −0.19 standard deviation, or about 5% (−0.19 divided by a range of 3.93), below that by single firms.

Similarly, a coefficient for DATE (in months) for the aggregate model shows that the level of product innovativeness is estimated to increase by 0.01 per month, or 0.12 standard deviation in 1 year (0.01 × 12 months), which translates to an increase in product innovativeness by 3.1% (0.12 divided by a range of 3.93) per year, or 15.3% during the entire 1988–93 period.

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arrangements) and horizontal cooperations (links were between similar functions, i.e. R&D consortium). The relationship between innovativeness and strategic linkage was significant ($p < 0.05$ in the first period, and $p < 0.01$ in the second period and in aggregate), which is consistent with Hypothesis 2. This finding suggests that horizontal cooperative relationships tend to increase the level of innovativeness of their product more than vertical cooperative or single-firm strategies.

Firm size was a strongly significant variable ($p < 0.01$) in both periods as well as in aggregate, with small firms being more innovative than large firms. Small firms also displayed strong positive coefficients. Small and large firms cooperating were also significantly likely to introduce more innvoative products than large firms in the second period ($p < 0.05$) and in aggregate ($p < 0.10$) but coefficients were considerably less than those for small firms. Thus, Hypothesis 3 was supported. These findings endorse the notion that small firms possibly unencumbered by the bureaucracy and conservative approach of large firms tend to come up with more innovative products to attract investors and customers. Additionally, cooperating firms of differing sizes (mixed cases of large and small firms) also seem to introduce more innovative products than large firms. The higher level of innovativeness of small and mixed-size firms substantiates the small-size firm's appeal to larger firms as a source of products and partners.

As hypothesized, type B industries were more innovative than type M industries ($p < 0.01$) in both periods and in the aggregate. With strong positive coefficients, Hypothesis 4a is supported. Our finding endorses the claim that revolutionary developments such as gene splicing and other biotechnological advancements transform the biochemical industry through 'technology fusion'. This finding seems to support the dynamic assertions of Auster (1992) that peak rates of technological linkages are highest in emerging industries, and of Schroeder (1990) that technology waves are at different levels or stages within industries. Hence, a life cycle relationship may exist between the level of innovativeness and specific industries or industry segments.

The match between the firms' industry and the product's industry yielded significant ($p < 0.10$) findings in both periods. In aggregate, MATCH was highly significant ($p < 0.01$). Products introduced in industries outside the firms' industry have a tendency to be more innovative than products introduced within the firms' industry. Support was found for Hypothesis 4b.

While the first period showed no significance ($p > 0.10$), the temporal intensity of innovativeness (DATE) has increased within our data set for the second period and in aggregate, exhibiting a strong, significant relationship ($p < 0.01$) between the level of innovativeness and the progression of time. Thus, Hypothesis 5 was supported. This finding is possibly the most ominous and suggestive of a hypercompetitive nature of competition for firms that do not nurture an environment that promotes not only continuous innovation but also continuously increasing innovativeness (D'Aveni, 1994; Dickson, 1992). With the progression of time comes an intensification of competition which is manifested by an increase in the speed of product replacement and levels of innovativeness. As explained in Table 1, the level of product innovativeness is estimated to have increased, on average, by 15.3 percent during the 1988–93 study period. This finding appears consistent with the notion that lead time is becoming more effective than patents in protecting a firm's competitive advantage (Levin *et al.*, 1987).

The nationality of the firm seemed to be little related to the innovativeness of the product except in the case of European products, which exhibited a significant result in the first period ($p < 0.01$) and in the aggregate ($p < 0.10$). The idea that new products introduced by firms of single-country origin might be more innovative than those introduced by cross-nationally cooperating firms was partially supported for European firms. While not conclusive, cultural difficulties might seem to affect cross-national cooperative strategies. Hypothesis 6 found partial support but does little to enlighten our understanding of the nature of nationality's effect on innovativeness.

The models for product innovativeness were highly significant in both the first period ($p < 0.01$) and the second ($p < 0.01$). The R^2 of the first period was 0.16 and remained stable at 0.16 in the second period. The aggregate model, with an R^2 of 0.13, was highly significant ($p < 0.01$) but explained slightly less of the variance than either of the disaggregated models.

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While relatively low, the R^2 values were consistent over time, suggesting that structural, rather than random, patterns exist in determining the level of innovativeness of products.

Phase 2

The purpose for the second phase of this study was to explore specifically the changes of cooperating firms' product innovativeness between the two periods (single-company product introductions were discarded so the variable NO_FIRM was unnecessary). The total number of cases of cooperating firms was 307. The independent variables, LINKAGE, SIZE, PRODUCT, MATCH, DATE, NATION, remained and a variable was added to represent agreement or accord between the cooperating firms' industries (COOP: intraindustry vs. interindustry cooperation). There was a question of a relationship between MATCH and COOP, so the analysis was run independently for each of these variables with the other dependent variables and then run with MATCH and COOP together. The findings remained stable, so MATCH and COOP were found to be fairly independent and both variables were maintained in the study.

The results of the ANCOVA for this phase were consistent with the first phase of the study. Therefore, only the newly added COOP variable needs to be discussed. The relationship between COOP and the level of innovativeness was significant ($p < 0.05$) in the first period and in the aggregate. The coefficient for interindustry cooperation indicated a likelihood of an increased level of innovativeness over products of intraindustry origin. For the second period, the coefficient estimate exhibited a positive coefficient but was not significant ($p > 0.10$). Hypothesis 4c was generally supported. This finding agrees with Killing's (1980) evidence that joint ventures undertaken with diversified partners have greater success than those with similar partners.

The phase 2 model for product innovativeness was significant in the first and second periods ($p < 0.01$). The R^2 of the first period was 0.16 and remained constant in the second period at 0.16, as in the first phase. Again the aggregate model was significant ($p < 0.01$) and explained slightly less of the variance ($R^2 = 0.13$) than the models for period one or two. Overall, these results show consistency and stability over time.

CONCLUSIONS AND IMPLICATIONS

This paper has explored the impact of cooperating firms, firm size, industry, strategic linkages, temporal aspects, and nationality on the innovativeness level of new products. Cooperative strategies were examined to refine and extend the understanding of innovativeness of high-technology product introductions, especially within the theory of competitive rationality and hypercompetition. The use of actual product introductions, inclusion of a consumer orientation, and development of multiple dimensions of the innovation construct produced a degree of external validity. However, our findings should be interpreted cautiously as the explanatory power (R^2) of the models is relatively weak. Strictly from a statistical point of view, the use of categorial variables reduces the model's explanatory power, but generates more conservative results than the use of quantitative variables. Therefore, our findings should be considered conservative.

The general findings suggest that small firms, horizontal linkages, and type B (e.g., biochemical) products are the strongest contributors to the level of product innovativeness. Additionally, single firms, mixed-size firms, cross-industry product offerings, cross-industry cooperations, and cooperating European firms are intermediate indicators of higher product innovativeness. The increasing intensity of competition as measured by the general progression of time also signaled a significant, positive effect on the level of innovativeness.

To understand the study's implications, a firm can be viewed as a collection of technologies ranging from simple administrative procedures to applied sciences (Porter, 1980). Cooperative strategies seek to coordinate two or more firms' technologies while eliminating the redundancies. Cooperating strategies are undertaken at the most efficient level to capture the maximum profits and market opportunities for the product (Dickson, 1992). Communication, coordination, and a multidisciplinary effort between and within firms is key to building trust and superior performance but must be balanced against the burden of these additional tasks, which could decrease the level or rate of innovation. Our research suggests that cooperating firm's efforts to achieve other benefits from the alliance

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negatively affected the innovativeness of their products. On the other hand, cooperating European firms' product innovativeness held out the possibility that cooperating firms can develop innovative synergy for their products.

One possible reason why cooperating firms' efforts had a negative impact on the products' innovativeness is their failure to balance competing demands. Management's orientation toward the primacy of either technology or strategy will affect the innovativeness of the products (Petroni, 1983a, 1983b). A complementary fit is needed between technology and strategy. It is also necessary to establish a shared perception of the relative value of each firm's contributions and a mutually acceptable division of profits (Spekman and Salmond, 1992). The results of our study could suggest that firms have had difficulty in finding the equilibrium point between the competing demands of cooperation and competition. Another possible explanation may be found in the inherent difficulty in recognizing the commercial potential and convincing other firms to cooperate in a venture involving a dramatic innnovation. Therefore, cooperating firms may tend to introduce less innovative products.

One of the principal forces driving competition is technological change. The gathering pace of technological change has demonstrated its power to influence the environment and create a competitive advantage for firms that can keep abreast and place technology in the context of their competitive strategy (Hayes and Abernathy, 1980). Rapid technological change leads to stunted diffusion curves resulting from inhibited diffusion rates as prospective adopters seek to avoid products which are quickly superseded (Gold, 1981). Apple Computer's announcement of the impending release of Newton more than a year ahead of its actual introduction had profound effects on the sales of competitors' palmtop computers and personal data assistants (PDAs). Diffusion researchers will increasingly find that diffusion models must account not only for contingent relationships (i.e., Bayus, 1987) and a decreasing time interval between successive generations (i.e., Norton and Bass, 1987), but also for increasing innovativeness and the effect of expectant, albeit non-existent, products.

A firm can use its innovative skills to shape the environmental conditions in its favor, to attract more competent partners, to communicate the greater benefits of the firm's products to the consumer, and to extract more favorable gains from cooperative strategies. Incrementally more innovative products and incrementally greater revenues compound in the long term to substantial advantages for the firm. Successful innovation generates change in the organization which can trigger the unraveling of a firm's existing strategy as new capabilities, structures, and relationships are frequently required to exploit innovation (Jelinek, 1986; Lengneck-Hall, 1992). Alternatively, organizations that are not actively involved in innovation may lose their ability to keep abreast of and deal with technological evolution (Kotabe, 1992; Tushman and Anderson, 1986).

Another managerial recommendation includes a warning that a company should constantly monitor within its own industry but even more importantly outside its industry for product technology. If a company is small, it can go it alone or attract a large partner without overly compromising the innovativeness of its efforts. If the firm is large, good sources for acquiring innovative products and partners are small firms. Industry differences occur and in this data set firms in the biotechnology industry have the greatest product innovativeness hurdle to overcome. Additionally, horizontal and cross-industry cooperative arrangements have contributed to the increase of product innovativeness but the overall tendency toward negative effects of cooperative strategies demands managers' attention.

Finally, it is not clear, however, whether increased product innovativeness is necessarily the most productive route to enhanced performance in all situations. Rapid product and process incremental innovation geared toward satisfying customer needs is vastly easier to maintain and less risky than committing the firm to a strategy of discontinuous product development (Czinkota and Kotabe, 1990). While the difference between the two may be reduced if the innovative effort is directed toward solutions to customer problems rather than corporations committed to an aggressive program of basic research, it is more likely that a balance must be struck between developing continuous and discontinuous innovations. The effect on innovativeness of technological push as opposed to market pull is unclear.

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LIMITATIONS AND FUTURE DIRECTIONS

Unfortunately, we cannot determine if the product introduction was successful on the market. Between one-third (Booz, Allen & Hamilton, 1982) and as high as three-fifths (Silk and Urban, 1978) of product introductions are rated as failures or of doubtful success. Seventy percent of the resources spent on new products are allocated to products that are not successful in the market (Booz, Allen & Hamilton, 1982). These dismal figures are for products that get to the introduction phase. Managerial relevance and implications for diffusion research would be greatly enhanced if factors of success for products could be included among the predictor variables. A follow-up study is recommended to clarify which combination of innovation types and product strategic advantages were more aligned with success of products after introduction.

Second, while simultaneous pursuit of multiple types of innovation for one product or of multiple strategies was not directly studied, exceptional companies manage both radical breakthrough and incremental technology change (Marquis, 1972). While only the dominant product attributes generate our findings, cross-boundary research as to how synergies between levels of innovation would arise and their effects would illuminate this area. Other research questions are whether simultaneous innovation on all levels is better than concentration on a single innovation, whether companies that have lost manufacturing ability can achieve long-term success, and whether strategic alliances allow these firms to continue to compete or allow competitors to appropriate their technology. Also, the level of resource investment tied to interdependence and commitment of the cooperation, explored by Auster (1992), would be an interesting variable with which to study product innovativeness.

Third, a more representative sample of product introductions over a longer period of time should be examined. A more accurate representation of the population of product introductions could solve possible biases such as the tendency toward computers, electronics, pharmaceuticals, and biochemicals. More innovative products are probably more newsworthy and might have been overrepresented in the sample. Other possible biases could include a slightly greater tendency to cover products introduced by large firms that have an interest to investors, although there are more small companies than large listed on the stock exchange. Finally, it is possible that cooperating firms are more newsworthy than single firms, although until a product is introduced the collaboration would not be included in the data set. While such biases may limit the range of the finding's application, the results of the study are robust, with important implications for product development, cooperative strategies, and theory refinement.

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