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Research on Innovation: A Review and Agenda for *Marketing Science*

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Innovation is one of the most important issues in business research today. It has been studied in many independent research traditions. Our understanding and study of innovation can benefit from an integrative review of these research traditions. In so doing, we identify 16 topics relevant to marketing science, which we classify under five research fields:

- Consumer response to innovation, including attempts to measure consumer innovativeness, models of new product growth, and recent ideas on network externalities;
- Organizations and innovation, which are increasingly important as product development becomes more complex and tools more effective but demanding;
- Market entry strategies, which includes recent research on technology revolution, extensive marketing science research on strategies for entry, and issues of portfolio management;
- Prescriptive techniques for product development processes, which have been transformed through global pressures, increasingly accurate customer input, Web-based communication for dispersed and global product design, and new tools for dealing with complexity over time and across product lines;
- Defending against market entry and capturing the rewards of innovating, which includes extensive marketing science research on strategies of defense, managing through metrics, and rewards to entrants.

For each topic, we summarize key concepts and highlight research challenges. For prescriptive research topics, we also review current thinking and applications. For descriptive topics, we review key findings.

Key words: innovation; new products; consumer innovativeness; diffusion models; network externalities; strategic entry; defensive strategy; ideation; rewards to entrants; metrics
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Introduction

Innovation, the process of bringing new products and services to market, is one of the most important issues in business research today. Innovation is responsible for raising the quality and lowering the prices of products and services that have dramatically improved consumers' lives. By finding new solutions to problems, innovation destroys existing markets, transforms old ones, or creates new ones. It can bring down giant incumbents while propelling small outsiders into dominant positions. Without innovation, incumbents slowly lose both sales and profitability as competitors innovate past them. Innovation provides an important basis by which world economies compete in the global marketplace.

Innovation is a broad topic, and a variety of disciplines address various aspects of innovation, including marketing, quality management, operations management, technology management, organizational behavior, product development, strategic management, and economics. Research on innovation has proceeded in many academic fields with incomplete links across those fields. For example, research on market pioneering typically does not connect with that on diffusion of innovations or the creative design of new products.

Overall, marketing is well positioned to participate in the understanding and management of innovation within firms and markets, because a primary goal of innovation is to develop new or modified products for enhanced profitability. A necessary component of profitability is revenue, and revenue depends on satisfying customer needs better (or more efficiently) than competitors can satisfy those needs. Research in marketing is intrinsically customer and competitor focused, and thus well situated to study how a firm might better guide innovation to meet its profitability goals successfully.

To encourage and facilitate further research on innovation in marketing, we seek to collect, explore, and evaluate research on innovation. Key goals of this paper are to provide a structure for thinking about innovation across the fields, highlight important streams of research on innovation, suggest interrelationships, and provide a taxonomy of related topics. Table 1 identifies five broad fields of innovation and various subfields within each of them. We hope this attempted integration will stimulate fertilization and interaction across fields and promote productive new research. This review attempts to summarize key ideas, highlight problems that are on the cusp of being addressed, and suggest questions for future research.

In the interests of space and relevance to marketing, our review is relatively focused. It does not include research on the antecedents of product development success (see Henard and Szymanski 2001 and Montoya-Weiss and Calantone 1994 for meta-analyses reviewing this research), the role of behavioral decision theory to inform product development (Simonson 1993, Thaler 1985), marketing's integration with other functional areas (Griffin and Hauser 1996), innovation metrics (Griffin and Page 1993, 1996; Hauser 1998), or the engineering aspects of product development (Ulrich and Eppinger 2000). Readers interested in an in-depth record of the extant literature can find an extended bibliography on www.msi.org, mitsloan.mit.edu/vc, and the *Marketing Science* Web site (http://mktsci.pubs.informs.org/).

Successful innovation rests on first understanding customer needs and then developing products that meet those needs. Our review of the literature, therefore, starts with our understanding of customers and their response to and acceptance of innovation. Because we are interested in how firms profit from innovation, the article then reviews organizational issues associated with successfully innovating and with how organizations adopt innovations. Customer understanding and the organizational context are underpinnings to innovating successfully. They must be in place before proceeding. The next three sections of the article then follow the flow of innovation: from first setting strategy in preparation for initiating development, through the prescriptions in the literature for moving the idea from conception and into the market, and ending with the rewards that accrue to innovators and defending against others entering.

The subsequent sections review each of the research topics within their corresponding research fields. When the research area is prescriptive, we attempt to summarize what can be accomplished and where the greatest challenges exist. When the research area is descriptive, we attempt to summarize the knowledge available today, the important gaps in that knowledge, and how that knowledge might lead to prescriptions.

Table 1 Classification of Research on Innovation

Research field	Research topic
Consumer response to innovation	Consumer innovativeness Growth of new products Network externalities
Organizations and innovation	Contextual and structural drivers of innovation Organizing for innovation Adoption of new tools and methods
Strategic market entry	Technological evolution and rivalry Project portfolio management Strategies for entry
Prescriptions for product development	Product development processes The fuzzy front end Design tools Testing and evaluation
Outcomes from innovation	Market rewards for entry Defending against new entry Rewarding innovation internally

Consumer Response to Innovations

"I don't want to invent anything that nobody will buy." *Thomas Alva Edison*

The success of innovations depends ultimately on consumers accepting them. Successful innovation rests on first understanding customer needs and then developing products that meet those needs. Our review of the literature starts with understanding customers. Research in many disciplines, but especially in marketing, has long sought to describe, explain, and predict how consumers (or customers[1]) and markets respond to innovation. A vast body of research has developed on the behavioral and decision aspects of this quest (Gatignon and Robertson 1985, 1991) and on the dynamics by which new products diffuse through a population (Rogers 2003).

Within this vast domain, we identify three subfields that have been particularly well researched or offer the most promise for managerial applications and future research: consumer innovativeness, models of new-product growth, and network externalities. Research on consumer innovativeness describes

[1] We use the terms consumers and customers interchangeably in the article. These include both current customers of the firm as well as potential consumers who do not currently purchase the firm's products but who have similar needs to current customers. Customers and consumers may be individuals, households or organizations, or institutions.

the mental, behavioral, and demographic characteristics associated with consumer willingness to adopt innovations. This research investigates adoption at the individual level. Models of new-product growth help firms understand and manage new products over their life-cycles. The diffusion literature focuses on understanding adoption at the aggregate level. Research on network externalities tries to understand the prevalence and effects of positive (or negative) feedback loops between consumers' adoption of a product and the product's value. This research focuses on understanding the relationship between individual-level adoption and patterns of aggregate adoption.

Consumer Innovativeness

Consumer innovativeness is the propensity of consumers to adopt new products. As Hirschman (1980, p. 283) suggested, "Few concepts in the behavioral sciences have as much immediate relevance to consumer behavior as innovativeness." Research on consumer innovativeness focuses on the characteristics that differentiate how fast or eagerly consumers adopt new products. We classify this research as focusing on the measurement of innovativeness, its relatedness to other constructs, and innovativeness variance across cultures.

Measurement. If innovativeness is a valid predictor for new-product adoption, then measures of innovativeness should identify those consumers most likely to adopt new products so that firms can target marketing efforts and improve forecasts. Over decades, researchers have developed and proposed numerous scales that differ in their theoretical premise, internal structure, and purpose (e.g., Midgeley and Dowling 1987). There has been no attempt to synthesize research or findings across all these different scales, although Roehrich (2004) has reviewed and classified them into two groups: (1) life innovativeness scales and (2) adoptive innovativeness scales.

The life innovativeness scales focus on the propensity to innovate at a general behavioral level. They describe attraction to any kind of newness and not to the adoption of specific new products. Kirton's (1976, 1989) innovators-adaptors inventory (KAI) is the most popular in this set of scales. However, because it taps innovativeness in general, its predictive validity tends to be low (Roehrich 2004).

The adoptive innovativeness scales focus specifically on the adoption of new products. Examples of these scales are Raju (1980), Goldsmith and Hofacker (1991), and Baumgartner and Steenkamp 1996). Raju's (1980) scale has good internal consistency, but Baumgartner and Steenkamp (1996) criticize it for its structure. Goldsmith's and Hofacker's scale (1991) measures domain-specific innovativeness, but Roehrich (2004) questions its discriminant validity. Baumgartner and Steenkamp (1996) developed a scale to measure consumers' tendency toward exploratory acquisition of products (rather than innovativeness per se). Exploratory acquisition is similar to innovativeness expressed in information seeking.

Despite extensive research, progress in this area has been hindered by a lack of consensus about a most appropriate scale. Actually, researchers have not yet agreed about a single definition of innovativeness. Current definitions vary from an innate openness to new ideas and behavior, to propensity to adopt new products, to actual adoption and usage of new products.

Relatedness to Other Constructs. Many researchers have used the measures of innovativeness to study its relationship to other constructs. Im et al. (2003), Midgeley and Dowling (1993), and Venkatraman (1991) explored the relationship between innovativeness and demographics. Foxall (1988, 1995); Foxall and Goldsmith (1988); Goldsmith et al. (1995); Manning et al. (1995); and Midgeley and Dowling (1993) studied the relationship between innovativeness and the adoption of innovations. Steenkamp et al. (1999) and Hirschman (1980) researched the relationship between innovativeness and other related constructs. While some studies have shown that innovators are better educated, wealthier, more mobile, and younger, other studies have failed to validate these findings (Rogers 2003, Gatignon and Robertson 1991). Another stream of research uses innovativeness measures combined with other observable characteristics such as marketing strategy, marketing communication, and category characteristics to predict actual trial probability for a new product (Steenkamp and Katrijn 2003).

This research is promising because it connects consumer innovativeness with observable characteristics. It could benefit from a synthesis with earlier models of pretest market analyses, such as Claycamp and Liddy (1969). In practice, many pretest market analyses often merge laboratory measures with "norms" based on past experience. The primary limitation of this literature is the lack of consensus on measures, scales, and methods of research. However, the adoption of new products by consumers is crucial to new product success. It is important to understand what drives consumers' propensity to adopt new products.

Variation Across Cultures. Currently there is a small but important effort to study the innovativeness of consumers across diverse cultures and countries. For example, Steenkamp et al. (1999) studied 3,000 consumers across 11 countries of the European Union. Tellis et al. (2004) studied over 4,000 consumers across

15 major countries of the Americas, Europe, Asia, and Australia. They find that innovativeness differs systematically across countries, although innovators also show certain demographic commonalities. Such analyses can throw light on optimal strategies for global entry. By using the same instrument across cultures, researchers can partly bypass the problem of choosing the appropriate scale. However, to obtain valid results, researchers need to ensure that the instrument is properly translated, back translated, and retranslated. They also need to control for cultural biases in responsiveness, such as reticence among east Asians or exuberance among southern Europeans.

Research Challenges. The key challenge is the need for a consensus among researchers on measures, scales, and methods of inquiry. This research would be facilitated with a deeper underlying theory that includes individual characteristics as well as the individual's relationship to the social network (e.g., Allen 1986, Souder 1987, Van den Bulte and Lilien 2001). Specific research opportunities include:

- Developing parsimonious, unified scales for consumer innovativeness that encompass the strengths of existing scales while avoiding their weaknesses;
- Using such a scale to study how or whether innovativeness varies across product category, geography, or culture;
- Identifying within-country differences in innovation that might be due to ethnic, cultural, demographic, or historical factors;
- Linking individual-level theories of innovativeness with social networks;
- Assessing the ability of innovativeness to predict the adoption of specific new products and, in particular, a synthesis with the prescriptive models of pretest market analyses;
- Incorporating measures of individual consumer innovativeness into models of new-product growth (reviewed in the next section).

Growth of New Products

Consumer innovativeness critically affects the adoption of new products and their subsequent growth. While the research on consumer innovativeness focuses on adoption at the individual level, the new product diffusion literature focuses on adoption at the aggregate level. The aggregate growth of new products has enjoyed intensive study in marketing over the last 35 years, beginning with Bass (1969) and now totaling over 700 estimates of the parameters of diffusion or applications of the model (Bass 2004, Van den Bulte and Stremersch 2004).

The Bass model expresses the adoption of a new product as a function of spontaneous innovation of consumers (due to unmeasured external influence) and cumulative adoptions to date (due to unmeasured word of mouth). The basic model is estimated using three parameters, which have been interpreted as the innovation rate (or coefficient of external influence), the imitation rate (or coefficient of internal influence), and the market potential. The ratio of these coefficients defines the shape of the sales curve and the speed of diffusion; their typical sizes are responsible for the commonly observed S-shape of new product sales for most consumer durables (Van den Bulte and Stremersch 2004).

The Bass model has had great appeal and widespread use because it is simple, generally fits data well, enables intuitive interpretations of the three parameters, and performs better than many more complex models. At the same time, the model has some limitations that subsequent research sought to address. First, the original model did not include explanatory variables, such as marketing-mix variables, that firms use to influence the imitation rate or total market potential. When included, these variables complicate specification and estimation. Second, the model's parameters are highly sensitive to the inclusion of new data points. Parameter estimates based on six years of data may be very different than estimates using eight years of data. Third, the original estimation by multiple regression suffered from multicollinearity. Fourth, estimating the model requires knowing two key turning points in early sales (takeoff and slowdown); however, once these events have occurred, the model's value is primarily descriptive or retrospective, rather than predictive.

A vast body of research has explored solutions to these and other problems. Examples of subsequent research include modeling:

- Dependence of the three key parameters on relevant endogenous and marketing or exogenous variables (e.g., Horsky and Simon 1983, Kalish and Lilien 1986, Kalish 1985);
- Improvements in estimation analytics, including maximum likelihood estimation (Schmittlein and Mahajan 1982), nonlinear least squares (Jain and Rao 1990, Srinivasan and Mason 1986), Bayesian estimation (Sultan et al. 1990), hierarchical Bayesian estimation (Lenk and Rao 1990, Talukdar et al. 2002), augmented Kalman filter (Xie et al. 1997), and genetic algorithms (Venkatesan et al. 2004);
- Dependence of diffusion on related innovations (e.g., Bayus 1987, Peterson and Mahajan 1978);
- Successive generations of innovation (e.g., Bass and Bass 2004, Norton and Bass 1987);
- Adopter categories (e.g., Mahajan et al. 1990);
- Variation of parameters across countries and their explanation by sociological, economic, and cultural factors (e.g., Gatignon et al. 1989, Putsis et al. 1997, Roberts et al. 2004, Takada and Jain 1991,

Talukdar et al. 2002, Van den Bulte and Stremersch 2004);

- Stages in the adoption process (e.g., Kalish 1985, Midgeley 1976);
- Supply restrictions (e.g., Ho et al. 2002, Jain et al. 1991);
- Continuous-time Markov models (Hauser and Wernerfelt (1982a, b);
- Repeat and replacement purchases (Lilien et al. 1981, Mahajan et al. 1984);
- Retailer adoption (e.g., Bronnenberg and Mela 2004) and spatial diffusion (Garber et al. 2004);
- Processes for interpersonal communication (e.g., cellular automata, Garber et al. 2004, Goldenberg et al. 2002);
- Cross-market communication (Goldenberg et al. 2002).

Detailed reviews of this area are available (Mahajan et al. 1990, Chandrasekaran and Tellis 2005). Rogers (2003) positions this research stream in a broader review of research on the diffusion of innovations. Sultan et al. (1990) and Van den Bulte and Stremersch (2004) provided meta-analytic estimates of model parameters. Mahajan et al. (1995) provided a summary of the empirical generalization of the research. These reviews suggest an emerging consensus on the following points:

- A plot of sales over time in the early years of the product life-cycle is generally S-shaped unless there is cross-market communication, in which case there may be a slump in sales.
- The S-shaped curve could emerge from social contagion among consumers or due to increasing affordability among a heterogeneous population of consumers.
- The S-shaped curve seems to hold for successive generations of the product.
- The coefficient of innovation is relatively stable and averages about 0.03.
- The coefficient of imitation varies substantially across contexts, with an average of about 0.4.
- The ratio of the coefficients of imitation to innovation is increasing over calendar time, indicating a faster rate of diffusion of new products.

Although the extant literature on the growth of new products is enormous, recent research in the area suggests new directions. First, there are some product categories for which a different pattern of adoption applies. For example, when weekly movie sales are plotted against time, the shape of the curve seems to decline exponentially, with a peak in one of the first few weeks (e.g., Eliashberg and Shugan 1997, Sawhney and Eliashberg 1996). This pattern holds for national and international sales (e.g., Elberse and Eliashberg 2003) and for theater and video sales (e.g., Lehmann and Weinberg 2000). A model based on the Erlang 2 distribution seems to fit weekly sales of movies better than the Bass model, suggesting that additional forces may be affecting movie sales differentially, such as initial marketing efforts, the impact of the distribution chain (movie theaters), or repeat viewing.

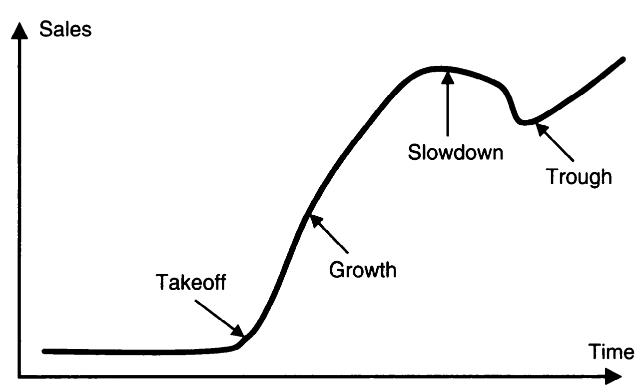
Second, the Bass curve seems to be punctuated by two distinct turning points—takeoff and slowdown—as illustrated in Figure 1 (Agarwal and Bayus 2002, Foster et al. 2004, Golder and Tellis 1997, Kohli et al. 1999, Stremersch and Tellis 2004, Tellis et al. 2003). Takeoff is the sudden spurt in sales that follows the period of initial low sales after introduction. Slowdown is a sudden leveling in sales that follows a period of rapid growth. Slowdown frequently is followed by what has been called a saddle, trough, or chasm (Goldenberg et al. 2002, Golder and Tellis 2004, Moore 1991). The above empirical studies over multiple categories of consumer durables suggest the following potential generalizations:

- New consumer durables have long periods of low growth before takeoff, steep growth after takeoff, and erratic growth after slowdown.
- The time to takeoff currently averages six years, the growth stage about eight years, and trough about five years.
- These patterns, especially time to takeoff, vary systematically and dramatically by country.
- New products take off and grow much faster in recent decades than in earlier ones.
- New electronic products have a much shorter time to takeoff and faster growth rate than other household durables.

Research Challenges. Despite substantial research, many challenges remain for future research, including:

- Exploring the generalizability of the S-shaped curve, the turning points, and the declining exponential growth curves across categories;

Figure 1 Stages of the Product Life Cycle



• Developing an integrated model to predict the turning points in the S-shaped curve, such as compound hazard models, multivariate regime-switching models, or time-series models with structural breaks;

• Exploring competing theories for the S-shaped curve and the turning points, such as social contagion, heterogeneity in proximity (crossing the chasm), heterogeneity in income (affordability), informational cascades, or network externalities (see below);

• Comparing the patterns and dynamics of new-product growth across countries, cultures, and ethnic groups;

• Determining whether and how network effects influence diffusion (see the next section).

Network Externalities

Consumer acceptance of new products and their subsequent growth can be affected greatly by network externalities. Network externalities refer to an increase in the value of a product to a user based on either the number of users of the same product (direct network externality) or the availability of related products (indirect network externality). For example, fax machines exhibit a direct network externality because the value of each node (fax machine) increases with more users who can receive or send faxes. DVD players exhibit an indirect network externality because the value of each DVD player increases as more DVD titles for the player become available. More titles will become available if there are more DVD players. Similar indirect network externalities exist for HDTV sets (available programming), alternative-fuel vehicles (refueling stations), and computer hardware platforms (software programs).

Many economists have studied whether firms become monopolies or grow and stay dominant in markets due merely to network externalities (e.g., Church and Gandal 1992, 1993; Farrell and Saloner 1985, 1986; Katz and Shapiro 1985, 1986, 1992, 1994). Based on this line of research, regulators have argued that Microsoft holds monopoly power in the operating system market, in part, because of network externalities: The Windows operating system and Office products are more attractive to customers because so many other customers own and use them.

Another premise that some economists have postulated is the existence of path dependence—early dominance of a market (due to early entry or some favorable event) might lead to the inability of subsequent superior products from ever becoming successful (Arthur 1989, Krugman 1994). A classic example cited in favor of this theory is the success of the QWERTY keyboard over the Dvorak keyboard, to which some researchers attribute performance superiority.

A major limitation of much of the past research is that it has been highly theoretical without systematic empirical testing of hypotheses and assumptions. A new stream of research has sought to test assumptions and hypotheses with detailed historical data. Some of these empirical researchers have concluded that the hypothesized inefficiencies or perverse outcomes of network effects may be greatly exaggerated (e.g., Liebowitz and Margolis 1999, Tellis et al. 2005). For example, Liebowitz and Margolis (1999) provide empirical evidence to show that the Dvorak keyboard never rivaled the QWERTY in real benefits to users.

Empirical studies in marketing have sought to estimate specific aspects of network effects, including existence (Nair et al. 2004), product introduction (Bayus et al. 1997, Padmanabhan et al. 1997), diffusion (Gupta et al. 1999), price competition (Xie and Sirbu 1995), marketing variables (Shankar and Bayus 2001), perception of quality (Hellofs and Jacobson 1999), product attributes (Basu et al. 2003), pioneer survival (Srinivasan et al. 2004), and dominant designs (Srinivasan et al. 2004).

Research Challenges. Important challenges for future research include:

• Understanding the role of quality, price, and product-line extensions versus network effects in fostering or hurting market efficiency;

• Understanding the role of network externalities in the takeoff, growth, and decline of products;

• Optimally managing the marketing mix in the presence of network externalities;

• Developing normative tools to help firms anticipate and manage network externalities;

• Evaluating the strength of network externalities and evaluating whether and to what extent network externalities lead to long-run competitive advantages;

• Understanding the interaction of network externalities with the product development process, design tools, organizing for product development, strategies of entry and defense, and models of consumer and market response.

Summary: Consumer Response to Innovations

Of the three topics considered in this section, the most focused, paradigmatic research has occurred on the growth of new products. However, integration of the three topics of research could provide new stimuli for research and new insights. For example, growth rates and the shape of the growth curve have predominantly been studied in independent products. They might change in the face of network externalities—an environment that is hypothesized to affect a larger proportion of new products. They also might change if firms can pinpoint innovative consumers or their role in the social network. More importantly, models of consumer response typically make simplifying assumptions about consumer innovativeness in order to model aggregate behavior. Research on consumer innovativeness focuses on micro behavior and measures of individuals, with minimal concern for aggregate market or network outcomes. An integration of these streams of research might allow for more insightful models with superior predictions.

Organizations and Innovation

People drive innovation, and (most) people work in organizations. As summarized in Table 1, we begin this section with research on the contextual and structural drivers of innovation. We then summarize research on how firms organize for innovation. The final subsection addresses how new methods and tools for improving product development are adopted by organizations.

Contextual and Structural Drivers of Innovation

Many authors have explored the characteristics of organizations that enhance innovation capability (Burns and Stalker 1961, Damanpour 1991, Ettlie et al. 1984, Hage 1980). These authors argue that unique strategies and structures, such as self-directed new venture groups charged with moving the firm into a new market, lead to radical process and product adoption. On the other hand, incremental process adoption and new-product introduction tend to be promoted in more traditional organizational structures and in larger, complex, and decentralized organizations.

These findings relate to the question of whether the size of the organization matters, a perspective rooted in Schumpeter's (1942) idea of creative destruction, in which innovations destroy the market positions of firms committed to the old technology. This research is ongoing, with at least five competing schools of thought. Galbraith (1952) and Ali (1994) posited that large firms have advantages such as economies of scale and the ability to bear risk and access financial resources, which enable them to innovate. They also might have specialized complementary assets, such sales and service forces and distribution facilities, which allow them to appropriate the returns from these new products more effectively than smaller firms without similar complementary assets (Levin et al. 1987, Tripsas 1997). On the other hand, Mitchell and Singh (1993) suggested that small firms are better equipped to innovate as inertia at large firms prevents them from making forays into entirely new directions. Ettlie and Rubenstein (1987) suggested that the relationship is nonmonotonic and that medium firms are best suited to innovate. Still another group (Pavitt 1990) argued that medium firms are most disadvantaged because they bear the liabilities of both small and large firms, but not the advantages. Perhaps the most interesting perspective is that of Griliches (1990), who analyzed the same data with a variety of models, finding that the data fit most of these hypotheses and that the outcomes depend heavily on the prespecification of the econometric function.

While size may be the most controversial of the structural drivers of innovation capability, researchers have explored many firm characteristics as they relate to innovative potential. This information was summarized by Vincent et al. (2004) based on a meta-analysis of 27 antecedents and three performance outcomes of organizational innovation in 83 studies between 1980 and 2003. They found that, in addition to 10 resource/capability factors, the following categories of factors are associated with a firm's ability to innovate:

- Environment: competition (+), turbulence (+), unionization (−), and urbanization (+)
- Structure: clan culture (+), complexity (+), formalization (+), interfunctional coordination (+), and specialization (+)
- Demographic: age (+), management education (+), professionalism (+), and size (+)
- Method factors: use of dichotomous measures of innovation (−), use of cross-sectional data (+), studied process versus product innovation.

Also associated with a firm's propensity to innovate is the extent to which the returns from innovation can be appropriated by the innovating firm. Levin et al. (1987) statistically uncovered two general dimensions of mechanisms by which firms appropriate innovation profits: legal mechanisms, such as patent protection, or secrecy combined with complementary assets. Patent protection is effective in only a very few industries, including chemicals, plastics, and drugs. Potential competition from direct imitators is muted in these industries with "tight" appropriability regimes, and so firms are driven to innovate continuously and to develop more radical new technologies (Teece 1988). Innovators in other industries with "weaker" appropriability regimes still will be driven to innovate when secrecy or complementary assets allow them to obtain returns from their innovations, even when those innovations do not perform as effectively as a smaller new entrant's product (Tripsas 1997).

In related research, Chandy and Tellis (1998) introduced the concept of "willingness to cannibalize" as a critical driver of a firm introducing radical innovations. They found that this variable was associated with having specialized investments, presence of internal markets, product champion influence, and a future market focus. Chandy et al. (2003) looked at the role of technological expectations on firms' investments in radical innovation and found that the fear of obsolescence is a more powerful motivator of investment in radical innovation than is the lure of enhancement. Moreover, dominant firms that fear obsolescence are much more aggressive in pursuing radical technologies than are their less-dominant counterparts with the same expectation.

Research Challenges. Whether firms wish to organize for innovation or they want to match organizational and innovation goals, they must understand the drivers of innovative potential. Some of the key unanswered issues are:

- Role of a firm's internal culture in influencing innovation, including factors such as willingness to cannibalize, visionary leadership, future market orientation, and customer orientation;
- Differences in the drivers of innovation by innovation type (product versus process), category (products versus services), and other characteristics; of particular interest are interactions, rather than just main effects;
- Impact of macroenvironmental factors such as research clusters, research incubators, and governmental policies (taxes, incentives, and regulation) on innovation;
- Impact of cultures and ethnicity on innovative capabilities.

Organizing for Innovation

While many contextual and structural variables affect innovation capabilities, one structural factor that the firm can control is how it organizes for innovation. Although organization structure and culture are sticky and difficult to change, firms can affect many organization aspects to improve innovation. We review four subareas of organizational research that are relevant for innovation and ripe for study: overall organizational forms, teams, cross-boundary innovation management, and commitment.

Organizational Forms. Larson and Gobeli (1988) asked managers to evaluate five project management structures against cost, schedule, and technical performance goals as mechanisms for organizing product development projects. They found that project-matrix and project-team structures performed favorably. More recently, researchers have advocated product development teams that are led by functional managers, project managers, or self-appointed champions. Clark and Fujimoto (1991) and Wheelwright and Clark (1992) recommended "heavy-weight" project managers as the best way to lead teams in mature, bureaucratic firms developing complex products (e.g., the auto industry). However, innovation also occurs in smaller firms, in geographically distributed teams, in fast-clock-speed industries, and for less-complex products, which might require different organizational forms to support innovation. For example, as organizational improvisation has been found to increase design effectiveness in situations of high environmental turbulence, such as is frequently found in high technology industries, less bureaucratic or more organic forms may be more useful organizing mechanisms in these instances. In other cases, functional managers might be appropriate leaders for particular stages of innovation. An R&D manager may effectively lead a radical innovation in the fuzzy front end. Finally, research has shown that champions are not consistently effective in many industries; more likely, they are indirectly linked with success (Markham and Aiman-Smith 2001, Markham and Griffin 1998). Most of the research on organizational forms was completed prior to the age of electronic communication. It is unclear whether the previous fits between organizational form and project context still prevail.

Teams. The composition of teams as well as leadership is important to innovation. Cross-functional teams are associated with higher firm success and faster new-product development (Griffin 1997a, b). However, cross-functional teams require that people be drawn from and interact with many internal stakeholders in the firm. Ancona (1990) suggests that successful teams include people in at least five important roles: ambassadorial (representing the team to key stakeholders), scouting (scanning the environment external to the team for new information), sentry (actively filtering incoming information), guarding (actively filtering outgoing information), and task coordination. More recently, in light of enhanced Web-based communication and increased geographic distribution, Sarin and Shepherd (2004) suggested that the influence of boundary management now is very different from that reported previously. Product development often takes place in virtual teams connected only by the Internet and working across geographic boundaries, time zones, and cultures. Because of this, specific sentry and scouting roles seem to be less important than in the past, with ambassadorial and coordination roles more important.

Cross-Boundary Management. Innovation is increasingly being managed across boundaries with names such as: codevelopment, development alliances, and development networks. Some codevelopment is done with competitors, some with suppliers, some with customers, and some with firms that have no relationship to the firm's current business, but bring a needed capability to the partnership. While it is a "hot topic" in the practitioner literature, and some initial research exists in the strategy literature, few research teams in marketing have entered this research arena. One exception is an empirical study of 106 firms that had participated in new-product alliances. Rindfleisch and Moorman (2001) found that both increased quality of the alliance relationship and increased overlap in knowledge base between alliance partners were associated with higher product creativity and faster speed to market. They also found that horizontal alliances—ones between competitors—were more likely to have higher overlap in knowledge bases, while vertical alliances, such as those with suppliers or customers, had higher quality relationships. Clearly, significant opportunity exists to investigate the impact of joint development projects (both horizontal and vertical) on product preferences, brand image, channel management, pricing, or marketing communications.

Commitment. The form of organization is related to the propensity of some teams to balance the risks and rewards of innovation. In some cases, managers overvalue projects and innovations in which they have already invested time, effort, and money. While such experience might be viewed as sunk costs, it affects careers and the motivations of managers. This research began with the work of Staw (1976), who showed that commitments to negative R&D decisions escalate with increasing responsibilities for those actions. This was explored further by Simonson and Staw (1992) and Boulding et al. (1997), who suggested strategies to deescalate commitment.

Research Challenges. Organization remains important for innovation, and many challenges remain for research in this area:

- Identifying when teams, cross-functional teams, virtual teams, or other organizational forms are best for innovation;
- Identifying what variables mediate the choice of team and team structure for different product strategies and contexts;
- Researching virtual teams and those that span geography, time zones, and cultures;
- Understanding the best form(s) of team leadership for fast-clock-speed and distributed environments;
- Investigating the best organizational forms for codevelopment projects;
- Understanding how codevelopment influences marketing strategies, tactics, and outcomes;
- Identifying the best organizational forms and incentive structures to motivate managers to kill futile projects.

Organizational Adoption of New Tools and Methods

Despite extensive research and development of tools to enhance the end-to-end product development process, organizations still struggle with the execution of those processes (e.g., Anderson et al. 1994, Griffin 1992, Howe et al. 1995, Klein and Sorra 1996, Lawler and Mohrman 1987, Orlikowski 1992, Wheelwright and Clark 1992). Firms struggle to adopt new tools or methods that would allow them to innovate more effectively.

Adoption failures often are due to communication breakdowns or suspicion among team members. For example, team members who are experts with an old tool fear losing status when a new tool is introduced. Another reason for failure is that benefits of the new tool are initially oversold. New methods are difficult to learn and implement and often divert effort from other aspects of product development (Repenning 2001). To overcome implementation problems, researchers have proposed boundary objects, communities of practice, and dynamic planning.

Boundary Objects. New methods are more likely to be used effectively if the product development team understands the dependencies across boundaries in the organization. Carlile (2002, 2004) has suggested that some objects, called boundary objects, improve communication among team members and enhance the adoption of new methods because they help the team work across organizational boundaries. Such boundary objects might include CAD/CAE tools, the House of Quality, and conjoint simulators, among other tools.

Communities of Practice. Knowledge about product development techniques and tools is often embedded in social groups within the organization (Lave and Wenger 1990, Wenger 1998). To ease the adoption of new methods, organizations need to tap this distributed (often implicit) knowledge. In recent years, firms have developed communities of practice whose purpose is to share and evolve process and domain knowledge. Operation of these communities, and knowledge flow from them, might be enhanced with Web-based tools.

Dynamic Planning. Repenning and Sterman (2001, 2002) have cautioned that the adoption of new methods is an investment that needs to be amortized over multiple projects. For example, when Boeing implemented "paperless design" on the 777 project, management understood and set the organizational expectation that the tool would not reduce development time on the 777 project, but would on subsequent ones. If firms demand an immediate return on a single project, they will undervalue the new method. It is also important to understand the interrelationships between manager expectations and the allocation of effort within product development teams. Managers and development teams need to manage expectations, allocate sufficient time to learn tools, and support their continued implementation across multiple projects before evaluating their success in an organization.

Decision Tool Implementation. Marketing science has produced some excellent prescriptions on how one might implement decision support tools. Little's (1970, 2004) decision calculus provides one set of guidelines that has stood the test of time. Sinha and Zoltners (2001) discuss the lessons they have learned in 25 years of implementing sales force models. Wierenga and van Bruggen (2000) provide further prescription. Firms implementing new tools for product development can learn much from these experiences in other domains.

Research Challenges. Many challenges for research on the adoption of new tools and methods remain, including:

- Understanding the organizational and cultural issues that explain why some tools and methods are accepted and used and others are not;
- Developing normative processes to aid the adoption of new tools and methods—such processes might combine boundary objects, communities of practice, and dynamic planning;
- Transferring the lessons learned in the implementation of marketing science tools in general to the implementation of product development tools.

Summary: Organizations and Innovation

Product development occurs in organizations, organizations that have cultures, structures, and operating processes already in place. Our review of organizations and innovation identifies many issues with great potential for research by marketing scientists. Many contextual issues are associated with the marketing tactics or product type (radical versus incremental, product versus service, etc.) that influence a firm's ability to innovate or to adopt innovations. The relationship between how organizations integrate across boundaries—especially those at the edge of the firm and the integration of marketing concepts into a product-development organization—are open fields for investigation.

Strategic Market Entry

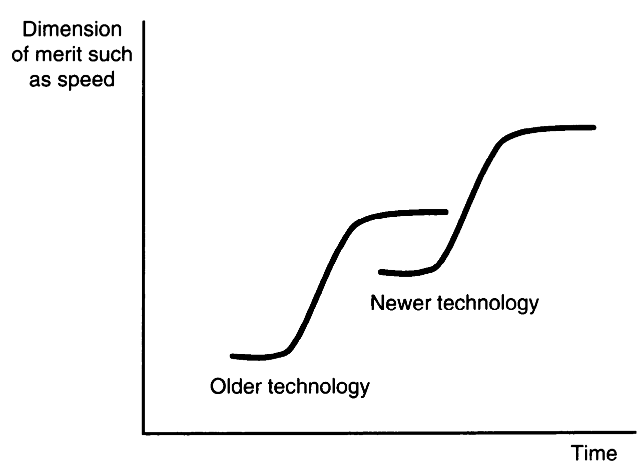
The previous sections reviewed how consumers respond to innovations and how firms should organize to adopt new innovations themselves, and to bring innovations to consumers. However, innovation rarely occurs in a vacuum. It is the strategic action of a firm that competes with rivals in a market. This section reviews the strategic issues associated with whether, when, or how a firm should innovate. We identify three subfields of research that address these issues: technological evolution and rivalry, project portfolio management, and strategies for entry.

Technological Evolution and Rivalry

Selecting the right technology to develop is critical to product development success. To make wise decisions about the technology and timing with which to enter markets, firms need to understand the rate, shape, and dynamics of technological evolution. Research in this area seeks to inform managers about the potential of rival technologies, when such rival technologies will be commercialized, when to exit the existing technology, and when to invest in rival technology.

Authors in the technology literature typically have focused on progress on a primary dimension of merit, often hypothesized as the most important customer need for a particular segment of consumers at the time the innovation emerges. Examples are brightness in lighting, resolution in computer monitors and printers, and recording density in desktop memory products. Based on this view, the dominant thinking in this field is that the plot of a technology's performance against time or research effort is S-shaped, as in Figure 2. That is, when a feature of interest, say capacity in disk drives, is plotted versus time, the technological frontier forms an S-shaped curve—a period of slow improvement during initial development, then a period of rapid improvement as the technology is advanced simultaneously by multiple firms, and then a plateau as the inherent performance limits of that technology are approached. The stylized model is that performance of successive technologies follows a sequence of ever higher S-curves that overlap with that of a prior technology just once (Foster 1986, Sahal 1981, Utterback 1994). For example, while one technology is in its rapid-improvement stage, a newer technology might be in its slow-improvement period. Later, when the older technology plateaus, the newer technology might be in its rapid-growth phase and pass the older technology in capability. Theories exist with contingencies for each of the three major stages of the S-curve: introduction, growth, and maturity (see Abernathy and Utterback 1978, Utterback 1994). These theories describe each of the stages as emerging from the interplay of firms and

Figure 2 Idealized S-Curves for Technological Evolution



researchers across the evolving dynamics of competing technologies.

Within this overarching theory of S-curves, Christensen (1998) introduced the concept of a disruptive technology—one that is inferior in performance to the existing technology, but cheaper or more convenient than it is and so appeals only to a market niche. The disruptive technology is shunned by incumbents but is championed by new entrants. It improves in performance until it surpasses the existing technology. At that point, the new entrants who championed the new technology displace the incumbents who cling to the existing technology.

While this literature is important and interesting, implicit assumptions limit the practical implications that can be drawn. First, a "disruptive technology" might be identified only post hoc, that is, after it has disrupted the business of incumbents (Danneels 2004). To make investment decisions, firms must be able to identify in advance which technologies will disrupt an industry and which will not. Second, the S-curve theory appears to be based on anecdotes rather than a single unified theory supported by large-sample cross-sectional evidence. Third, the theory ignores cases where new and old technologies coexist and improve steadily. Examples include (1) incandescent and LED lighting; (2) copper, fiberoptic, and wireless communications technologies; and (3) CRT, LCD, and plasma video displays. For example, in an initial study of 23 technologies across six categories, Sood and Tellis (2005) suggested that prototypical S-curves that cross only once fit the data for only a minority of technologies. Fourth, evolution in technology might be due to changing preferences across needs rather than an S-curve on a single need.

There is no good evidence that all technologies follow S-curves (Danneels 2004). Older technologies often coexist with newer technologies for many years; e.g., fluorescent lighting provides more light at lower cost, but incandescent lighting remains a viable technology (Sood and Tellis 2005). Faucet-based home water filtration is much less expensive per gallon, but the market for pitcher-based water filtration remains strong. Hybrid vehicles have significantly better fuel economy, but they remain a niche product and likely will remain so for many years to come. Hydrogen-powered vehicles are still in technology development.

Marketing methods can enlighten this debate by recasting the focus from a (supply-side) product- or technology centric one to a (demand side) customer-centric one. For example, $3\frac{1}{2}$" disk drives surpassed $5\frac{1}{4}$" disk drives in part because customers started demanding smaller size and lower power consumption for portable computers. Initial laptop customers were willing to make trade-offs, accepting lower capacity for smaller size. Similarly, pitcher-based water is stored at refrigerator temperatures. Customers are willing to sacrifice filtration efficiency for better perceived taste. When viewed from a compensatory model of consumer decision making, perhaps measured with conjoint analysis, the new technology was an improvement in overall consumer utility (for some consumers) relative to the previous technology.

By building customer response directly into the theory of technological evolution, marketing researchers could transform the debate on disruptive technology and provide normative tools for technology selection early in product development. For example, Adner (2002) uses simulation to suggest that disruptive dynamics are enhanced when the preferences of the old segment of the market (e.g., desktop personal computer users) overlaps with those of the new segment of the market (e.g., portable computer users). Adner and Levinthal (2001) use similar simulations to suggest that demand heterogeneity is an important concern as firms move from product to process innovation. These and other customer-oriented explanations of technology adoption have the potential to redefine the disruptive technology debate. Such consumer-oriented perspectives complement rather than replace theories of technology supply and development.

Research Challenges. The theory of the S-curve of technological evolution has been popular in academia, while the thesis of disruptive technology has been popular in the trade press. However, future research needs to carefully critique, validate, and refine these concepts and theories so that they might enable managers to make good decisions on market entry. Importantly, the dynamics of customer demand for alternative product features and the heterogeneity of customer preferences as they relate to customer segments may have the potential to provide a fundamental theory to understand the interaction of technology and customer response (e.g., Adner 2002, Adner and Levinthal 2001). Among the research challenges are:

- Ascertaining if (and when) the S-curve of technology evolution is valid, and identifying the platform, design, and industry contexts across which it applies;
- Developing a single, strong, unified theory of the S-curve if it is true. Alternatively, developing new theories that describe how technologies evolve, compete, dominate, or coexist with a rival;
- Clearly delineating the types of innovations, such as platforms, that start a new technology (new S-curve) from those that sustain improvements in performance (advances along an S-curve);
- Modeling predictions of whether and when an old technology is likely to mature or decline and a new technology is likely to show a jump in

performance—so managers can avoid prematurely abandoning a promising technology;

- Integrating a customer perspective into the theory of S-curves, which is currently mostly a theory of technological evolution;
- Integrating theories of technology evolution (S-curves) with marketing theories of the evolution of customer needs and strategic positioning;
- Developing practical tools to identify when new customer needs are becoming important and could thus lead to disruption in the market.

An analysis of technological evolution and rivalry enables a firm to appreciate the market environment in which it must compete. Before it can decide on its own steps, it needs to assess the portfolio of resources that it currently has. The next section reviews literature on portfolio management.

Project Portfolio Management for Product Development

A firm's overall profitability results from the portfolio of products it commercializes over time and across product lines. Managing the portfolio means making repeated, coherent strategic investments in markets, products, and technologies. Because not all projects survive the development process, some firms simultaneously initiate multiple projects that target the same market, but do so using different technical approaches. For these firms, optimal pipeline structures (how many projects to initiate using different approaches) can be modeled as depending upon the magnitude of the business opportunity, cost (by stage) of developing each project, and survival probabilities of the project at the completion of each stage. When Ding and Eliashberg (2002) compare optimal recommended pipeline structures to actual numbers of projects initiated across eight pharmaceutical development categories, they find that the leading firm in the category has fewer projects in development than they should. At least for this industry, maximizing firm profit means managing the project portfolio both across and within market segments over time to produce a continuous stream of new products.

Research on the selection of a product portfolio suggests that success requires an effective process that includes both strategy and repeated review to create a balanced, profit-maximizing portfolio (Cooper et al. 1997, 1998, 1999). Top-performing firms use formal, explicit processes, rely on clear, well-defined procedures, apply these procedures consistently, and include active management teams. Although financial approaches dominate portfolio decisions, Cooper et al. (1999) suggested that scoring approaches, used in conjunction with strategic focus, yield the most profitable innovation portfolios.

While most research in marketing has focused on tools and methods to design a portfolio of products for a target market (or on game-theoretic insights into the characteristics of product portfolios), research in product development has begun to focus on project selection and set management as means to obtain a balanced, profitable portfolio (Blau et al. 2004, Bordley 2003, Sun et al. 2004). Differences in ratios of line extensions, product improvements, and new-to-the-world (or radical) products impact financial outcomes (Sorescu et al. 2003). Technological diversity and repeated partnering enhance radical innovation (Wuyts et al. 2005). Whether the project is a platform or derivative product and how architecturally modular the product is will impact the choice of product development process and affect a firm's ability to obtain consumer reactions, and it may change the choice of the organizational home for the project (Ulrich 1995, Wheelwright and Clark 1992).

Finally, in a departure from explicit optimization, many firms have begun treating product development projects as options. Because data are often difficult to obtain, this approach is often referred to as "options thinking" rather than options analysis (Faulkner 1996, Morris et al. 1991). For example, General Electric and Motorola now use a three-horizon growth model to balance risk and to enhance a long-term perspective (Hauser 1998, Hauser and Zettelmeyer 1997).

Due to space constraints, we have chosen not to review the many game-theoretic models of portfolio strategy. Game-theoretic models have provided important insight by simplifying product development decisions to highlight strategic considerations. Many important and difficult research challenges remain to connect these strategic models to the prescriptive literature.

Research Challenges. The area of project portfolio selection and management is relatively new to marketing. There have been some excellent game-theoretical analyses, but researchers are only beginning to think about how these analyses can be implemented in real product development processes and how they might handle complex products in which literally millions of design decisions need to be made. The interesting challenges in this area are:

- Improving procedures to select projects to achieve a strategic portfolio;
- Merging game-theoretic ideas with the real challenges in selecting a line of complex products for heterogeneous customers whose needs vary on a large number of dimensions;
- Improving (and generalizing) methods to relate portfolio decisions to future performance outcomes;
- Understanding how contextual differences in industry and in the characteristics of the portfolio goals affect project selection;

• Developing methods to manage risk and long-term perspectives through options thinking methods.

Strategies for Entry
Once a firm has a good understanding of technological evolution, it needs to decide how to exploit that evolution given its own resources and portfolio of products, the resources and strategies of its rivals, and the dynamics of consumer demand. One of the best ways to achieve competitive advantage and gather monopoly profits is to lead the curve of technological evolution and protect one's lead by patents. However, gaining patent protection is not always possible. Even with patent protection, rivals can find ways to innovate around a patent. Thus, practically, most entry decisions also must consider the potential for and patterns of likely defense by competitors. We briefly review entry strategies here, because these decisions must be taken prior to starting the innovation process. We review strategies for defending against entry in a later section of this article because, temporally, the necessity of defending one's position occurs after a rival product has been launched. Clearly, however, the literatures on entry strategies and strategies for defending against entry are linked, and it would behoove a firm entering a new market to consider what defensive actions rival firms are likely to be considering. Many of the citations we provide under defensive strategy are also relevant for entry strategy.

Much of the research on strategic entry has been undertaken as theoretically derived models of potential behavior. Two modeling views of the situation have predominated.

Preemption Strategy. In some cases, based on the technological frontier, an incumbent (or even an initial entrant) has sufficient information to anticipate future entry. This is the classical preemption strategy. The incumbent firm (or entrant) selects its product positioning (customer benefits) to maximize its profits while anticipating future entry. Such analyses usually assume sufficient symmetry among firms to obtain analytical solutions and, as such, do not rely on unique core competencies. In some analyses, firms might preannounce new products, leapfrog generations of technologies, establish a product-line defense, or invest optimally in future product development. For example, Bayus et al. (2001) argued that preannouncement of new products is a means by which firms can signal their investment in resources, and intentional vaporware is a means of discouraging rivals from developing similar products. In other analyses, firms might stay one step ahead of the competition by introducing innovations that cannibalize their own successful products.

Technological Races. In some cases, it is clear that a new technology is on the horizon, say hydrogen power for automobiles. However, realizing the benefits of the new technology with a product that satisfies customer needs at a reasonable cost requires R&D success. It is not clear, a priori, which firm will be first to market. Such analyses tend to focus on the strategic decisions made under the uncertainty of the technological race. Few analyses have considered how marketing can be used to enable the losers of technological races to enter and differentiate a market.

Ofek and Sarvary (2003) studied the persistence of leadership in high-tech markets. They found that technological competence can encourage a leader to invest for technology leadership, while the presence of reputation effects can encourage a leader to underinvest in technology, leading to alternating leadership between a duopoly of firms. Ofek and Turut (2004) examined the trade-off between leapfrogging versus catch-up imitation when firms have the option of researching the market to reduce uncertainty. They found that firms may innovate "blindly" without such research even when its costs are negligible. Lauga and Ofek (2004) further explored on which attribute firms should innovate, given uncertainty about market demand and the option of costly market research.

In one of the few empirical pieces of research in this area, Chandy and Tellis (2000) examined whether new entrants are more likely to introduce radical innovations than are incumbents. They found that before World War II, small firms and new entrants were more likely to introduce radical innovations. In contrast, the pattern has changed dramatically since World War II, when large firms and incumbents were more likely to introduce radical innovations.

Research Challenges. Strategies for entry have received growing attention in marketing science. There are many analyses in this area, each with different assumptions and focus. Thus, the area is ripe for synthesis. In addition, many opportunities remain, especially for empirical research that seeks generalizations of firm behavior. Some important research challenges are:

• Developing empirical generalizations on what technology and marketing strategies firms actually use for entry;

• Understanding the effect of the degree of innovation (status quo, incremental innovation, or leapfrogging) on successful entry;

• Understanding the effect of product portfolios (status quo, line extensions, brand extensions, or new platforms) on successful entry;

• Untangling the mitigating effect of firm positions (incumbents versus entrants, strong versus weak market position, or low-cost versus high-technology positions) for effective entry strategies;

• Understanding the impact of message (preannouncements, vaporware, positioning, framing) on successful entry;

• Determining whether and when firms should use a rapid entry strategy (sprinkler) versus a sequential entry strategy (waterfall) when considering entry in multiple markets or multiple countries.

Summary: Strategic Market Entry
From the perspective of strategic entry, the research underpinning the issues comes from three different disciplines. Marketing could contribute materially to moving our understanding forward in each area. Research on technology entry originates in the management of technology literature. This topic would clearly benefit by adding a customer-oriented (demand) perspective to the supply-side focus that has predominated to date. Much of the recent literature on product portfolio management has either used a game-theoretic approach (in marketing) or has been more prescriptive (in the product development literature) in nature. Knowledge in this area would benefit from merging these two approaches to generate new insights. Finally, research on strategic entry has been dominated by a game-theoretic modeling approach published in both the marketing and economics literatures. Marketing could enrich our knowledge of this topic through empirical research that tests the theoretical predictions.

Prescriptions for Product Development
Once consumer needs are understood and organizations for innovating and strategies are in place, then begins the executional part of innovation—moving from having a strategy to conceiving a concept to delivering against that strategy, to designing the final product and its manufacturing process, to finally having a (hopefully successful) commercial product. This section examines research that has sought to improve this process of product development (PD), which is predominantly prescriptive in nature. We build on earlier reviews from the management literature (e.g., Brown and Eisenhardt 1995) by focusing on recent developments from a marketing science perspective. We begin with a brief review of product development processes, then discuss research applicable to each of three generic stages of product development (the fuzzy front end, tools to aid product design, and testing and evaluation).

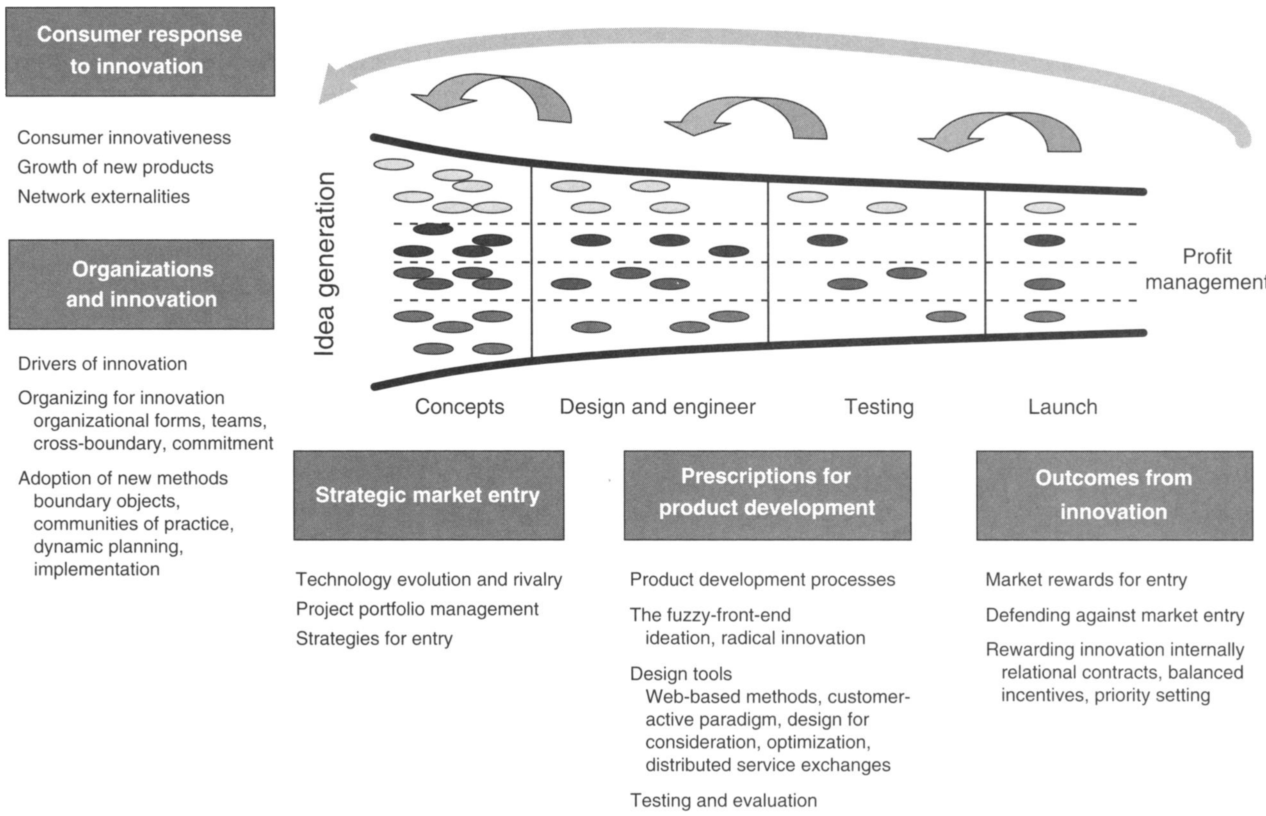
Product Development Processes
The emerging view in industry is of product development as an end-to-end process that draws on marketing, engineering, manufacturing, and organizational development. The core of this process is the product development funnel of opportunity identification, design and engineering, testing, and launch, shown in the center of Figure 3. Each oval in the funnel represents a different product concept. The funnel recognizes that, for a single successful product launch, failures will be many, although some may be recycled, reworked, and improved to become successful products. Even when a product has been in the marketplace, innovation continues as the firm continually searches for new opportunities and ideas. The funnel also recognizes the current hypothesis that firms are most successful if they have multiple product concepts in the pipeline at any given time, forming a portfolio of projects (as reviewed in the previous section). These projects might relate to independent products but increasingly are based on coordinated platforms to take advantage of common components and/or economies of scope.

Risk is inherent in product development; few of the many concepts in a portfolio are likely to be successful. Information to evaluate alternative concepts is often imperfect, difficult to obtain, and hard to integrate into the organization. For each success, the process begins with 6 to 10 concepts that are evaluated and either rejected or improved as they move from opportunity identification to launch (Hultink et al. 2000). While risk is inherent, it can be managed.

Most firms organize the work of product development as a series of gates in a process that has become known as a "stage-gate process" (Brown and Eisenhardt 1995; Cooper 1990, 1994). For example, in one "gate," the product development team might be asked to justify the advancement of a concept from idea generation to the design and engineering stage. While there are important practical considerations in the continuous improvement of stage-gate processes, the basic structure is well understood. Research has shown that use of a formal process is associated with increased success and shortened times for product development (Griffin 1997a). Ding and Eliashberg (2002) provide formal models to determine the optimal number of projects in each stage of the pipeline. While stage-gate processes continue to remain important for practice, research opportunities for stage-gate processes consist of developing incremental improvements for the process and better understanding decision making at each gate (Hart et al. 2003).

The fundamental research opportunity is the study of alternatives to stage-gate processes. For example, one recent modification is a spiral process (Boehm 1988, Garnsey and Wright 1990). In a spiral process, the product development (PD) team cycles quickly through the stages from opportunity to testing. Ideas are winnowed in successive passes, with the goal that each successive pass through the process proceeds at greater speed and lower cost. The theory of spiral processes puts a premium on speed while forcing the team to get engineering and market feedback quickly and often. Proponents expect that spiral processes have real advantages for software development (frequent "builds") and for products in rapidly evolving

Figure 3 Product Development—End to End



markets (Cusumano and Yoffie 1998). Relative to Figure 3, a spiral process has many more feedback loops and, more importantly, the entire process is repeated many times as the product "spirals" to completion (many repetitions of the top arrow in Figure 3).

Another alternative to a strict stage-gate process is overlapping stages (Cooper 1994, Wheelwright and Clark 1992). For example, engineering design might begin before the end of idea generation, and testing might begin with products that are not yet fully engineered. Some firms now involve a "marketing engineer" at early stages of the PD process—a team member charged with facilitating the design for ultimate marketing. The theory of overlapping stages is similar to that for spiral processes: greater speed and more rapid feedback.

The discussion and debate in the field has reached the stage where research is necessary to determine which process is best for which contexts. For example, overlapping stages may be more appropriate than spiral processes for products with greater engineering requirements that must move more linearly through the PD process. Cooper (1994) suggests that less-complex projects can use a simplified stage-gate process with fewer stages and gates. This research direction was highlighted by Brown and Eisenhardt (1995) but remains unresolved. Based on research to date, we suggest at least six contextual dimensions worth researching: (1) fast versus slow industry clock speed, (2) innovation within a current business versus opening a new business space, (3) radical versus incremental innovation (in technology and/or customer needs), (4) high versus low modularity, (5) low versus high product complexity, and (6) physical goods versus services.

Fast vs. Slow Clock Speed. These issues, well known in supply chain management (e.g., Fine 1998), apply equally well to the choice of a PD process. Sequential processes have been successful in slow-moving industries such as consumer packaged goods, whereas spiral processes are being adopted by some fast-moving industries such as software and high technology. Some degree of sequential completion is required in a number of businesses affected by regulatory agencies. For example, the federal Food and Drug Administration requires proof of certain outcomes before the various stages of clinical testing can begin.

Current vs. New Business. Innovation supporting current business lines is constrained by strategy, potential cannibalization, brand image, existing engineering and manufacturing resources, and current marketing tactics. Sequential processes can draw on engineering, customer, and market knowledge. However, innovation launched into the "white space" between business units often requires new resources, new knowledge, new strategy, and new ideas. The innovator must learn quickly about segments or customer needs and preferences. Spiral or overlapping processes may encourage and enable rapid experimentation and knowledge acquisition to innovate into this white space.

Radical vs. Incremental Innovation. Most product development efforts result in incremental innovations (Griffin 1997a). Sequential processes are effective for developing evolutionary products. Radical innovation—fivefold performance improvements along key customer needs or 30% or more in cost reduction—often requires developing products with an entirely new set of performance features (Leifer et al. 2000). As a result, the unknowns and risk are enormous compared to those in incremental development. Effective processes must provide a means to manage risk. For example, Veryzer (1998), in an exploratory study of eight firms, found formal, highly structured processes less appropriate for radical innovation.

High vs. Low Modularity and High vs. Low Product Complexity. When the design of a product or service can be decomposed into more or less independent components (a highly modular design) and/or when the product design is not complex, sequential processes may work well. However, consider a high-end copier, which requires thousands of components, or an automobile that requires many hundreds of person-years of effort to design. Such high complexity or integration requires intermediate "builds" to effect integration and test the boundaries of component performance. Software is an extreme example, where builds might occur weekly or even nightly. High integration and high complexity often require spiral processes.

Physical Goods vs. Services. The majority of all research on sequential PD processes has focused on physical goods. There has been less research on PD processes for services, which are intangible, perishable, heterogeneous, simultaneous, and coproduced. Menor et al. (2002) reviewed service development and suggested that the challenges for physical goods apply to services, but with the added complexity of developing the means to handle the unique nature of services within either sequential or spiral PD processes.

Research Challenges. PD processes are only as good as the people who use them. Structured processes force evaluation, but evaluation imposes both monetary and time costs. Teams can be tempted to skip evaluations or, worse, justify advancement with faulty or incomplete data. There are substantial research opportunities to understand the optimal trade-offs among evaluation costs, the motivations of teams for accuracy, and the motivations of teams for career advancement. For example, advancing a concept to the next stage in either a sequential or spiral process requires a hand-off. New team members must have sufficient data to accept the hand-off. In some instances, the old team members are now required to look for new projects—a disincentive to advancing a concept through the gate.

Marketing, with its tradition of research on people, whether they be customers or product developers, has many research streams that can inform and advance the theory and practice of PD processes. For example, the choice of a sequential versus a spiral or overlapping process is likely to depend upon how often and how effectively firms can obtain customer feedback. Despite this, we have seen little formal investigation of the link between marketing capabilities and PD processes. The most critical research challenges in this area include:

- Improving the effectiveness of nonsequential PD processes;
- Understanding which process is best in which situations;
- Understanding when it is appropriate to modify processes;
- Linking marketing capabilities and PD processes;
- Understanding the explicit and implicit rewards and incentives that encourage PD teams to either abide by or circumvent formal processes.

The Fuzzy Front End

Conceptually, early decisions in product development processes have the highest leverage. This is mitigated somewhat by spiral processes, but there is no doubt that the "fuzzy front end" of a PD process has a big effect on a product's ultimate success. If in this stage a firm can identify the best market opportunity, technological innovation, or set of unmet customer needs, then the remaining steps become implementation. While this conventional wisdom remains to be tested systematically, recent years have seen interesting research on the fuzzy front end of PD. Since Smith and Reinertsen (1992) coined the phrase, researchers in technology management have worked to identify factors associated with successfully completing the fuzzy front end and managing (or "defuzzifying") front-end processes more effectively (Khurana and Rosenthal 1997, Kim and Wilemon 2002, Koen et al. 2001). We focus on two aspects of the fuzzy front end that can be addressed effectively with research in marketing—ideation and the special issues associated with moving radical innovations through the fuzzy front end.

Ideation. Idea generation (ideation) long has been recognized as a critical start to the PD process. Early work on brainstorming led to structured processes based on memory-schema theory to encourage participants to "think outside the box." For example, the methodology developed by Synectics helps teams "take a vacation from the problem," while de Bono encourages lateral thinking and the "six-hats" method of seeing the problem from different perspectives (Adams 1986, Campbell 1985, de Bono 1995, Osborn 1953, Prince 1970). Many popular-press books propose alternative processes to foster the creation of unorthodox ideas. For example, the design firm IDEO promotes its approach to brainstorming through rules such as sharpen the focus, write playful rules (defer judgment, one conversation at a time, be visual, encourage wild ideas), make the space remember, and get physical (examine competitive products, build prototypes). See Kelly and Littman (2001). While these processes have proven effective in some situations, the stories are mostly anecdotal and highlight only the successes. Opportunities exist for comparative research to identify which methods work best in what contexts and behavioral research to identify why. For example, many researchers in marketing focus on how consumers make decisions. Many of the theories being developed and explored, such as schema theory or context effects, might inform the effectiveness of idea generation methods and procedures. More recently, research has been done on three methodologies developed to create structure within ideation: templates, TRIZ, and incentives.

Goldenberg and colleagues (e.g., Goldenberg et al. 2001; Goldenberg et al. 1999a, b, c) propose that most new product concepts come from thinking "inside the box" with creative templates that transform existing solutions into new solutions. A template is a systematic means of changing an existing solution into a new solution. Templates consist of smaller steps called "operators:" exclusion, inclusion, unlinking, linking, splitting, and joining. For example, the "attribute dependency" template operates on existing solutions by applying the inclusion and then the linking operators. Other templates include component control (inclusion and linking), replacement (splitting, excluding, including, and joining), displacement (splitting, excluding, and unlinking), and division (splitting and linking). The authors provide practical examples and presented evidence that templates account for most historic new products and enhance the ability of teams to develop new ideas.

TRIZ (Theory of Inventive Problem Solving) is another "in-the-box" system used widely by PD professionals (e.g., Altschuler 1985, 1996). Based on patterns of previous patent success, TRIZ has PD teams apply inventive principles to resolve trade-offs between a limited set of "competing" physical properties (approximately 40 in number). Marketing has paid little attention to TRIZ, but research opportunities exist to study its relationship to the customer's voice in comparing the multiple technical alternatives generated. For example, marketing researchers might compare TRIZ to creative templates to identify which is better and under which circumstances.

Studying the role of incentives in the ideation process, Toubia (2004) used agency theory to demonstrate that some reward systems encourage further exploration, wider searches, and more effort than others. Based on the theory, he developed an ideation game in which participants are rewarded for the impact of their ideas, not the ideas themselves. The ideation game uses economic theories of mutual monitoring to reduce free-riding and minimize the cost of moderation. Early successes suggest that the game is fun, effective, and produces ideas of significantly higher quantity and quality than other ideation processes.

Radical Innovation in the Fuzzy Front End. With step-change leaps in performance or cost reductions, radical innovations have the potential to provide the firm with profits and long-term competitive advantage (Chandy and Tellis 2000, Sorescu et al. 2003). However, rather than starting from market needs, radical innovation frequently starts from technology capability. These projects, due to their technology-development nature, spend a long time in the fuzzy front end. While there is an active stream of research and publications on this topic by innovation researchers, less has been published in the marketing literature. The Radical Innovation Research Program at Rensselaer Polytechnic Institute has used qualitative, longitudinal research to identify key research hypotheses about managing radical innovation, especially during the fuzzy front end of development (Leifer et al. 2000). The research suggests that it is important to identify the customers and markets who will find the innovation most appropriate first and to find ways to query these customers about concepts and technologies that are outside their realm of experience (O'Connor and Veryzer 2001, Urban et al. 1996, Urban et al. 1997). There are many challenges, relative to incremental products, when moving these technologies from the laboratory to the market (Markham 2002, O'Connor et al. 2002).

Research Challenges. While research has begun on the fuzzy front end of product development, key research challenges remain. Marketing researchers have the theories (modified from the theories of consumer behavior) and the orientation (that of the customers' perspective) to provide new directions to the study of idea creation and the creation of radical and disruptive technologies. Opportunities include:

- Evaluating the relative merits of structured ideation methods (in the box) versus mental-expansion ideation methods (out of the box);

- Developing and testing behavioral theories to identify the methods and processes that are most likely to enhance idea creation;
- Developing methods to understand initial applications and obtain customer needs and wants for radical innovation, especially from lead users and in novel situations;
- Developing methods to connect technology leaps with market and needs understanding;
- Developing methods to manage technologies through the fuzzy front end.

Design Tools

Suppose that the product development (PD) team has addressed the fuzzy front end to identify an attractive market to enter and has generated a series of high-potential ideas to enter the market. The market might be defined by a technology (digital video recorders), by a competitive class (TiVo, DIRECTV), by a set of high-level customer needs (control my television viewing experience), or by some combination of technology, competitive class, and customer needs. In both sequential and nonsequential processes, the PD team now seeks to design and position a product or product-line (platform) offering relative to these customer needs, technologies, and competitive classes. (In nonsequential processes this step might be revisited many times.)

The field of marketing has been extremely successful in developing, testing, and deploying tools to aid in the design of new products. Methods include research on customer perceptions and preferences (Green and Wind 1975, Green and Srinivasan 1990, Srinivasan and Shocker 1973), product positioning and segmentation (Currim 1981; Green and Krieger 1989a, b; Green and Rao 1972; Hauser and Koppelman 1979), and product forecasting (Bass 1969; Jamieson and Bass 1989; Kalwani and Silk 1982; Mahajan and Wind 1986, 1988; McFadden 1973; Morrison 1979). On conjoint analysis alone there are over 150 articles in the top marketing journals. In this section we highlight some of the new directions, including Web-based methods for improving customer inputs to design, the customer-active paradigm, design for consideration, product-optimization design tools for improving product design decisions based on customer inputs, and distributed PD service exchange systems that help marketing and engineering simultaneously make better decisions.

Web-Based Methods for Improving Customer Inputs to Design. With the wide availability of Web-based panels, more firms are moving their research on customer perceptions and preferences to the Web. Such panels enable research to be accomplished much more rapidly and with an international scope. While early indications suggest that such Web-based panels provide accuracy that is sufficient for product development, the evidence to date is anecdotal. There is ample opportunity for systematic studies of the reliability and the validity of Web-based panels.

Web-based methods, coupled with rapid algorithms and more powerful computers, enable design tools to be interactive and interconnected (see review in Dahan and Hauser 2002). For example, Toubia et al. (2004), Toubia et al. (2003), and Hauser and Toubia (2005) have developed adaptive methods for both metric and choice-based conjoint analysis that appear to be accurate with far fewer questions than traditional methods. Such adaptive methods enable PD teams to explore more product features and to explore them iteratively in spiral processes. Other Web-based methods, such as the idea pump, focus on qualitative input by encouraging customers to define both the questions and answers and thus identify breakthrough customer needs that lead to disruptive new products. Fast, dynamic programming algorithms can now search potential lexicographic screening rules so fast that lexicographic estimation problems that once took two days now can be solved in seconds (Martignon and Hoffrage 2002, Yee et al. 2005). These algorithms make noncompensatory conjoint analysis feasible. Finally, methods based on support-vector machines promise to handle complex interactions among product features (Evgeniou et al. 2004, Evgeniou and Pontil 2004, Abernathy et al. 2004).

Customer-Active Paradigm for Designing Products. The marketing function's customer connection knowledge and skills have been shown to be positively related to new product performance (Moorman and Rust 1999). Long prior to this empirical finding, von Hippel (1986, 1988) advocated using customers as a source of new-product solutions and ideas. For example, Lilien et al. (2002) analyze a natural experiment at 3M in which lead-user methods led to both more innovation and more profitable innovation. Recognizing the ability of customers to innovate, von Hippel and others have developed tools that enable customers to design their own products. In these tools, known variously as innovation toolkits, design palettes, user design, and configurators (Dahan and Hauser 2002, Thomke and von Hippel 2002, von Hippel 2001), customers are given a set of features and allowed to configure their own product. These toolkits are often quite sophisticated and include detailed engineering and cost models. For example, when a customer seeks to change the length of a truck bed, the design palette computes automatically the additional cost and the required changes in both the engine and the transmission. The design palette might even adjust the slope of the cab for aesthetic compatibility. While these toolkits are becoming available, research on their impact on customer decisions has just begun (Liechty et al. 2001, Park et al. 2000). Virtual advisors are another source of customer input. For example, Urban and Hauser (2004) demonstrated how to "listen in" on customers who seek advice on new trucks. Customers reveal their unmet needs by the questions they ask.

Design for Consideration. Traditional preference measurements, such as voice-of-the-customer methods and conjoint analysis, are based on a compensatory view of customer decision making (Green and Srinivasan 1990, Griffin and Hauser 1993). Models assume that customers are willing to sacrifice some performance on one feature, say personal computer speed, for another feature, say ease of use. For most product categories, this assumption is reasonable and provides valuable insight for new potential concepts. However, increasingly, product categories are becoming crowded. Over 300 make-model combinations of automobiles are available. Ninety-seven models of PDAs are available from one university's supplier. Furthermore, customers are increasingly using Web-based searches to screen products for inclusion in their consideration sets. J. D. Power (2002) reports that 62% of automobile purchasers search online. Such Web-based searches often allow customers to sort products on key features. General Motors, in particular, considers its greatest design challenge in the 2000s to be the ability to design products that customers will consider. General Motors feels that if it can encourage more customers to consider GM vehicles, the engineering team will feel pressured to design automobiles and trucks that will win head-to-head evaluations within the consideration set. As a result, General Motors has invested heavily in Web-based trusted advisors, directed customer relationship management, and other trust-based initiatives (Barabba 2004, Urban and Hauser 2004).

With good information-search tools available, and with the increasing number of alternatives being offered in many product categories, firms are studying when customers use decision heuristics, such as lexicographic, conjunctive, or disjunctive decision processes, to screen products (e.g., Bettman et al. 1998, Bröder 2000, Einhorn 1970, Gigerenzer and Goldstein 1996, Johnson and Meyer 1984, Martignon and Hoffrage 2002, Payne et al. 1993). Understanding decision heuristics helps PD teams identify the "must-have" features that will get their products into these consideration sets. Traditional models, which assume compensatory decision making, may miss these features. While there has been extensive experimental and econometric research on noncompensatory decision making (above citations plus Gilbride and Allenby 2004, Hauser and Wernerfelt 1990, Jedidi and Kohli 2005, Jedidi et al. 1996, Gensch 1987, Gensch and Soofi 1995, Kohli et al. 2003, Roberts and Lattin 1997, Swait 2001, Wu and Rangaswamy 2003, Yee et al. 2005), only recently have researchers begun to develop the measurement tools to identify noncompensatory processes and measure their impact as they relate to the identification of opportunities in product development.

Product-Feature and Product-Line Optimization. There is a long history of product optimization in marketing (see reviews in Green et al. 2003 and Schmalensee and Thisse 1988). These methods have sought to identify either an optimal product positioning or an optimal set of product features. With the advent of more powerful computers, improved models of situational consumer decision-making processes, greater understanding of competitive response, and improved optimization algorithms in operations research, we expect to see a renewed interest in the use of math programming to inform product design. This convergence and the resulting renewed development of optimization tools may be enhanced by the advent of new distributed PD service exchange systems, which allow marketers and engineers to increase decision simultaneity.

Distributed PD Service Exchange Systems. Product development can be complex. For example, typical electromechanical products might require close to a million engineering decisions to bring them to market (Eppinger 1998, Eppinger et al. 1994). Even software products require disaggregated yet coordinated processes involving hundreds of developers (Cusumano and Selby 1995, Cusumano and Yoffie 1998). Furthermore, PD teams are often spread over many locations, use different software, and have different worldviews. Coordination is a challenge.

To reduce communication time and effort and to effect compatible analytical systems, researchers have developed distributed service exchange systems (Senin et al. 2003, Wallace et al. 2000). These systems rely on service (and data) exchange with compatible objects rather than just a data exchange. For example, the voice-of-the-customer team might invest in a conjoint analysis of the features of a new computer (speed, data storage capacity, price, etc.) and build a choice simulator that predicts sales as a function of these features. The physical modeler might build a computer-aided design (CAD) system in which physical characteristics of a disk drive are input, and capacity and speed are output. The systems modeler might have a platform model that takes the dimensions of the disk drive and models its interactions with other components of the computer. Each of these teams, and many others, require and generate information that is connected through a virtual integrative system—each node takes input from the others and provides the needed output. When these distributed objects are interconnected, the PD team can test conceptual design rapidly without needing to build the physical product. Such systems reduce dramatically the time required to cycle through the stages of the PD process. These distributed systems are particularly useful when coupled with spiral or overlapping PD processes. One of the most difficult tasks in designing these systems is creating the ability to access and work with non-numeric data such as audio, video, and even text (Zahay et al. 2004).

Other researchers are integrating engineering tools such as analytic target cascading with marketing tools such as hierarchical Bayes choice-based conjoint analysis, for product-line design (Michalek et al. 2004, Michalek et al. 2005). These integrated tools are promising because they can be linked to marketing positioning strategy and decisions on the one hand, and to specific engineering design and manufacturing decisions on the other hand.

Research Challenges. Research on the development of design tools is mature, but thanks in part to the increases in computing speed and electronic connectedness of individuals, many challenges remain. Not only must these tools be consistent with both sequential and nonsequential processes, but they also need to be coordinated throughout the PD process(es) from the fuzzy front end to launch and profit management. The advent of fast interconnected computing combined with new developments in optimization and machine-learning algorithms has the potential to transform the ability of PD teams to use customer input, connect that customer input to design decisions, and to communicate within and between teams. Such a transformation could dramatically change the effectiveness of PD processes. There are also many broader challenges, including:

- Taking advantage of fast computers and Web-based interviewing to change research methods to be more adaptive, engaging the customer in new and interesting ways;
- Developing new methods to take advantage of the customer-active paradigm;
- Studying further situations in which it is difficult for customers to express their needs;
- Developing practical methods to incorporate ideas from behavioral decision theory to enable firms to design products to enhance consideration;
- Developing practical methods to optimize the product line's total offerings and integrate customer needs, engineering models, and competitive response;
- Building platforms that link engineering and marketing decision making and constraints into integrated systems;
- Integrating the tools, which are often developed in isolation, into a comprehensive and easy-to-use system for prescriptive product development.

Testing and Evaluation

In both sequential and nonsequential PD processes, designs must be tested before the firm ramps up investment. Interest continues on testing and evaluating product concepts, engineering solutions, and product positions. Prior research on beta testing, pretest markets, prelaunch forecasting methods, information acceleration, and test markets has provided PD teams with the ability to evaluate designs accurately and at a cost much lower than that of a full-scale product launch. See reviews in Dolan and Matthews (1993), Narasimhan and Sen (1983), Ozer (1999), Shocker and Hall (1986), and Urban et al. (1997). Recent advances in modeling heterogeneous customer response with hierarchical Bayes and/or latent-structure analyses provide the potential to monitor and evaluate designs at a much greater level of detail and accuracy. For example, General Motors is exploring the use of hierarchical Bayes methods combined with continuous-time Markov models to evaluate the impact of new strategies as they affect the flow of customers from awareness to consideration to preference to dealer visits to purchase.

Research Challenges. Research challenges for testing and evaluation, a relatively mature area of research in PD, share many of the same characteristics as the challenges for design tools:

- Taking advantage of fast computers, Web-based multimedia capabilities, and new adaptive algorithms;
- Integrating marketing, engineering, and manufacturing evaluation;
- Incorporating optimization and coordination into current research methods.

Summary: Prescriptions for Product Development

Prescriptive research focuses on how firms can improve their product-development processes, develop better fuzzy-front-end ideas, use better design tools, and test innovations effectively. Our selective review of this area has focused on issues that have high potential for contributions by researchers in marketing science. Many of the opportunities arise from the enormous increases in computing power and from the increased electronic interconnectedness between individuals on teams, and between those teams and both suppliers and potential customers. While alphanumeric information is relatively easy to incorporate into improving decision making in product development, we are still challenged with incorporating sensory data (visual, tactile, taste) into tools, methods, and processes for improving product development.

Outcomes from Innovation

If all goes well, the outcome of innovation is a product launched into the market that generates sales and profits for the firm. At the same time, that new entry likely will create performance challenges for incumbent products, causing firms to take steps to defend their position against the new entry to minimize the damage it does to their business. We end this article with a review of the expected outcomes from market entry. We start with market rewards for entry that provide the incentive for firms to enter markets. We then review research on how incumbents can defend against new entry. We close with research on how firms must internally reward employees' innovation by metrics-based management.

Market Rewards for Entry

Rewards for introduction of new products can be evaluated at the firm level, or for individual projects. Griffin and Page (1996) found that the construct is multidimensional, at whatever level of analysis is being mentioned. They also found that slightly different measures of success were more appropriate depending on the firm's innovation strategy (prospector, imitator, defender, or reactor) for firm-level measures and depending upon the project type (new-to-the-world, major improvement, incremental improvement) for project-level measures.

At the firm level, empirical research suggests that, on average, about 32% of firm sales and 31% of firm profits come from products that have been commercialized in the last five years (Griffin 1997a). Best practice firms realize about 48% of sales and 45% of profits from products commercialized in the past five years. These numbers have been relatively stable over the past decade, despite the improvements made in product development processes, methods for managing portfolios, techniques for obtaining customer input and understanding needs, and in marketing, engineering, and design. Companies need to continually evolve and improve their innovation capabilities just to stay even in terms of success.

In addition to the empirical research on average performance across the portfolio, there has been a significant stream of project-level research investigating success at the project level. Much of the innovation literature has focused on determining success antecedents at the project level using various measures of "success" as the dependent variable (see Henard and Szymanski 2001 and Montoya-Weiss and Calantone 1994 for reviews and meta-analyses).

Another stream of project-level research examines the relationship between timing of entry and rewards. Entering a market first often has advantages. For example, arguments in favor of early entry include shaping consumers' preferences, establishing consumer loyalty and/or switching costs, gaining cost and performance advantages from early sales, establishing and maintaining standards, and preempting preferred patents, suppliers, channels and locations. However, there are also advantages to waiting if later entrants can learn from early entrants' mistakes, take advantage of later technology, and benefit from industry learning (cost and technology), especially if it is hard to preempt patents, suppliers, channels or locations.

Early papers in marketing (e.g., Robinson and Fornell 1985, Urban et al. 1986) provided strong and consistent support suggesting market-share rewards to pioneers. An average measure of this reward across several studies is about 16 market-share points for pioneers over late entrants and 10 market-share points for pioneers over early entrants (Tellis and Golder 2001). Pioneers seem to have advantages in terms of broader product line and the ability to hold higher prices, achieve lower costs, achieve broader distribution coverage, enjoy better trial, and enjoy lower price elasticity (e.g., Kalyanaram and Urban 1992, Robinson and Fornell 1985). The pervasiveness of slotting allowances, especially for new products (Rao and Mahi 2003), may be construed as an additional disadvantage to late entry. Well-known national brands (probably earlier entrants) are less vulnerable to entry of private labels than are second-tier brands (Pauwels and Srinivasan 2004).

Kalyanaram et al. (1995), Kerin et al. (1992), and Lieberman and Montgomery (1988) have provided substantive reviews of the field. Support for the generalization about a strong pioneering advantage became so strong that the popular press began to call it the first law of marketing (Ries and Trout 1993). However, the studies supporting these results mostly used survey data (PIMS and Assessor databases), and occasionally scanner data.

In contrast to the above studies, a small but growing body of empirical studies have questioned the advantages to pioneers. Golder and Tellis (1993) point out two problems with the use of survey data for research on market pioneering: the inability to survey failed pioneers (survival bias) and the tendency of successful late entrants to call themselves pioneers (self-report bias). Both biases exaggerate the reported advantage of pioneers. Using an historical method to minimize these problems, the authors found that pioneers typically have low market share, mostly fail, and are rarely market leaders (Golder and Tellis 1993; Tellis and Golder 1996, 2001). VanderWerf and Mahon (1997) carried out a meta-analysis of empirical studies on the effects of market pioneering. They found that studies that used market share as the criterion variable were sharply and significantly more likely to find a first-mover advantage than tests using survival or profitability. Boulding and Christen (2003) treat the order of entry as endogenous and find that being first to market leads to a long-term profit *disadvantage*.

Theoretical research has emerged to explain various empirical findings regarding entry timing. Early studies developed theories to explain why and how pioneers might have long-term advantages (Carpenter and Nakamoto 1989, Gurumurthy and Urban 1992, Schmalensee 1982), while more recent studies have developed theoretical models to explain the disadvantages of pioneering or the advantages of late entry (e.g., Narasimhan and Zhang 2000, Shankar et al. 1998).

Research Challenges. The area of rewards to entrants has been studied intensely, albeit only in the past two decades. Many challenges for research remain, including:

- Understanding the differential effect of project type on project success;
- Understanding the relationship between the portfolios of commercialized products and firm rewards;
- Understanding how and when first-mover incumbents respond through further innovation;
- Theoretical research to explain innovation performance at the firm (portfolio) level;
- Developing new data or methods to account for survival bias and self-report bias; one option might be explicit modeling of these biases;
- Developing new data and analyses to examine whether advantages other than market share accrue to market pioneering, such as product-line breadth, patents, prices, price elasticity, costs, distribution, and profits;
- Assessing the link, if any, between network externalities (reviewed in a previous section) and the rewards to the order of market entry;
- Researching the interrelationship of order of entry and organizational issues including the contextual and structural drivers of innovation, the choice of organizational structure, and the metrics by which the process is managed;
- Understanding the potential long-term link between market power that results from pioneering advantage and subsequent investments in innovation to maintain that advantage.

Defending Against Market Entry

Despite attempts by an incumbent to preempt entrants, new firms do enter existing markets, successfully offering new combinations of benefits to customers. This produces the classical defensive strategy problem. The incumbent firm must adjust its product positioning and marketing tactics to maintain optimal profits. Numerous game-theoretic models have been developed to investigate outcomes, given various assumptions about the situation being modeled. Such analyses normally assume asymmetric core competencies of firms and further assume that the entrant has entered optimally, anticipating the response by the defender. Related analyses assume that the firms are already in the market and must select their price and positioning strategies. With perfect symmetry, the solutions are often ambiguous. However, slight asymmetries are usually sufficient to establish stable equilibria to enable better understanding of how the markets will shake out or evolve. Research in this area is diverse and has not yet led to any convergence in findings or conclusions. Some illustrative studies and findings in this area follow.

Hauser and Shugan (1983) proposed an optimal marketing-mix defensive strategy for an incumbent under attack. These methods have been applied empirically (Hauser and Gaskin 1984), have been shown to hold under equilibrium conditions (Hauser and Wernerfelt 1988), and provide similar insights when all firms in the market are allowed to respond (Hauser 1988). The major theoretical conclusions are that, under attack, firms should build on their current strengths relative to the attacker and, except for highly segmented marketing, reduce price and spending on distribution and awareness advertising. Profits typically decrease due to the entrant, but the optimal defensive strategy will maintain them at the highest feasible level.

Purohit (1994) examined the level of innovation and type of strategy of an entrant as they relate to the most appropriate defensive strategy. He concluded that increasing the level of innovation was the best response to entry by clones. The optimal level of innovation is determined by the strategy the firm adopts: product replacement, line extension, or upgrading. Nault and Vandenbosch (1996) addressed the related problem of timing the launch of a new-generation product to defend one's current position. They concluded that when faced with entry, under most conditions, it is optimal for incumbents to launch the new-generation product first.

This area also has empirical research. Robinson (1988) examined firms' reactions to new entry using the PIMS data. He found that most incumbents do not react to entry in terms of marketing mix, product, or distribution, as the scale of entry of the new entrant is often too small. It takes at least a year to observe an incumbent's response. In contrast, Bowman and Gatignon (1996) found reactions to be quicker for incumbents with a higher market share, threatened by smaller competitors, and operating in markets that are growing fast or have frequent changes in products. Bresnahan et al. (1997) study the market for personal computers in the 1980s to show that differentiation leads to an ability to earn excess profits by insulating brands from competitive response. Debruyne and Reibstein (2004) found that in the brokerage industry, incumbents were more likely to defend their position by entering niches when new entrants of similar size and resources did so.

Research Challenges. This area has received growing attention in marketing science. However, many opportunities remain, especially for empirical research that seeks generalizations of firm behavior. There are many analyses in this area, each with different assumptions and focus. The area is ripe for synthesis. Some of the important research challenges are:

- Developing empirical generalizations on what technology and marketing strategies firms actually use for defense;
- Understanding the effect of the degree of innovation (status quo, incremental innovation, or leapfrogging) on successful defense;
- Understanding the effect of product portfolios (status quo, line extensions, brand extensions, or new platforms) on successful defense;
- Untangling the mitigating effect of firm position (incumbent versus entrant, strong versus weak market position, or low-cost versus high-technology positions) for effective defensive strategies;
- Understanding the impact of message (preannouncements, vaporware, positioning, framing) on successful defense.

Rewarding Innovation Internally

Product development is exceedingly complex (Eppinger et al. 1994, Eppinger 1998). To address complexity and to provide both managerial control and incentives for the product development team, researchers have suggested that teams be managed (and rewarded) by metrics. While quantitative metrics are tempting, they can lead to adverse behavior. Consider the strategy of rewarding team members for the success of a new product by tying implicit rewards (promotion, advancement, exciting projects) to the ultimate market success of a product. If team members are risk averse, such incentives may motivate them to take fewer risks than are optimal and to bet on safe technologies, safe markets, and line extensions. Similarly, if team members are rewarded only for their own ideas and not for those from outside the firm, they will adopt a "not invented here" attitude and spend too much time on internal projects relative to exploring new technologies and new markets (Hauser 1998). Recent research has begun to address how to adjust team incentives and to select higher-level metrics to avoid some of this adverse behavior.

Relational Contracts. Research in agency theory suggests that formal incentive mechanisms are not sufficient to "induce the agent to do the right thing at the right time" (Gibbons 1997, p. 10). In real organizations, formal mechanisms are often supplemented with informal qualitative evaluations based on long-term implicit relationships (e.g., Baker et al. 1999). This is particularly important when decisions are delegated to self-managed PD teams.

Balanced Incentives. Cockburn et al. (2000) suggested that new tools and methods are adopted more quickly if they are complementary to methods already in use by an organization. They illustrated their suggestions with science-based drug discovery in the pharmaceutical industry, which requires organizations to adopt more high-powered incentives within the research organization. Perhaps the best-known example of balanced incentives is the balanced scorecard used extensively in industry and by the military (Kaplan and Norton 1992).

Priority Setting. Another stream of research takes the metrics as given and seeks to adjust the emphasis on alternative metrics to maximize the profit of the firm. By approximating the profit surface with a Taylor's Theorem expansion, it is feasible to apply adaptive control theory to adjust incentives in the direction that maximizes profit (Hauser 2001, Little 1966). For example, in one application, profits were increased dramatically by placing less emphasis on component reuse and more emphasis on customer satisfaction (Hauser 2001).

Research Challenges. Although marketing scientists have recently become extremely interested in metrics to evaluate marketing effectiveness, this research has not been well connected to the research on PD metrics, most of which has been published outside the field of marketing. There are opportunities to complement and expand this metrics research based on lessons learned within the field of marketing science. Research opportunities in the area of metrics-based management include:

- Identifying the appropriate metrics based on explicit models of the product development team's incentives (agents);
- Empirically testing hypotheses for relational contracts and balanced-incentive theory;
- Developing practical models for setting and adjusting priorities for innovation.

Summary: Outcomes from Innovation

Our review of research on market entry rewards, defending against market entry and internal rewards for innovation covers a wide range of topics, from the purely empirical to the purely theoretical. Rewards to entry depend on being able to commercialize the right set of products at the right time at the right price. Defending against market entry often depends upon models of and data on consumer response. Much of this research has occurred in marketing, although some highly relevant topics have been initiated in related disciplines. Our review also indicates a large number of topics, several with substantial extant research. Even so, many research opportunities remain. Such opportunities extend from developing better measures for team-based success to increased understanding about appropriate entry timing, given the product context.

Conclusion

Innovation is vitally important for consumers, firms, and countries. Research on innovation has proceeded in a number of disparate fields in a variety of disciplines. Some research areas are prescriptive; others descriptive; and still others have been theoretically developed but not empirically substantiated. Some are mature; others nascent. Some fit squarely within marketing; others have not been perceived as "marketing" topics. All can be enlightened by or can enlighten a marketing perspective. And, as empirical research has shown, firms need to keep improving their innovation capabilities just to stay even in terms of performance.

This article seeks to summarize, review, and integrate key areas of research on innovation that are relevant to marketing science. We endeavored to highlight convergent learning from multiple fields and perspectives, yet showcase the exciting opportunities for research that remain. While substantial progress has been achieved in each of the five domains of innovation in the framework of Table 1 and Figure 3, progress has not been equivalent across each of them.

We hope that by relating various topics and providing integrating perspectives, we will enable cross-fertilization between marketing and other disciplines and promote productive research. Research in these areas is intense, interesting, and exciting. It has solved major problems, discovered novel phenomena, and coalesced around important generalizations, yet major challenges remain for future research. We hope our readers agree.

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