

PRODUCT DEVELOPMENT: PAST RESEARCH, PRESENT FINDINGS, AND FUTURE DIRECTIONS

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The literature on product development continues to grow. This research is varied and vibrant, yet large and fragmented. In this article we first organize the burgeoning product-development literature into three streams of research: product development as rational plan, communication web, and disciplined problem solving. Second, we synthesize research findings into a model of factors affecting the success of product development. This model highlights the distinction between process performance and product effectiveness and the importance of agents, including team members, project leaders, senior management, customers, and suppliers, whose behavior affects these outcomes. Third, we indicate potential paths for future research based on the concepts and links that are missing or not well defined in the model.

Innovation research splits into two broad areas of inquiry (Adler, 1989). The first, an economics-oriented tradition, examines differences in the patterns of innovation across countries and industrial sectors, the evolution of particular technologies over time, and intrasector differences in the propensity of firms to innovate (e.g., David, 1985; Dosi, 1988; Nelson & Winter, 1977; Urabe, Child, & Kagono, 1988). The second, an organizations-oriented tradition, focuses at a microlevel regarding how specific new products are developed (e.g., Ancona & Caldwell, 1992b; Clark & Fujimoto, 1991; Zirger & Maidique, 1990). Here, the interest is in the structures and processes by which individuals create products. In this article, we focus on this latter area of the broader innovation literature.

Product development is critical because new products are becoming the nexus of competition for many firms (e.g., Clark & Fujimoto, 1991). In industries ranging from software to cars, firms whose employees quickly develop exciting products that people are anxious to buy are likely to win.

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In contrast, firms introducing "off-the-mark" products are likely to lose. Product development is thus a potential source of competitive advantage for many firms (Brown & Eisenhardt, 1995). Product development is also important because, probably more than acquisition and merger, it is a critical means by which members of organizations diversify, adapt, and even reinvent their firms to match evolving market and technical conditions (e.g., Schoonhoven, Eisenhardt, & Lyman, 1990). Thus, product development is among the essential processes for success, survival, and renewal of organizations, particularly for firms in either fast-paced or competitive markets.

During the past 10 years, the pace of product-development research has quickened as numerous academic scholars have probed the secrets of product-development prowess (e.g., Ancona & Caldwell, 1990; Clark & Fujimoto, 1991; Dougherty, 1990; Zirger & Maidique, 1990). Interest in product development plus preachings about the importance of proficient product development have reverberated in the popular press (*Business Week*, 1992; Dumaine, 1991; Schendler, 1992). The underlying rationale appears to be that, although technical and market changes can never be fully controlled, proactive product development can influence the competitive success, adaptation, and renewal of organizations. However, because this large and fragmented literature has not been tied together to create cogent understanding, it is difficult to grasp what is actually known. Thus, the purpose of this article is to improve the understanding of product development.

We begin by organizing the empirical literature on product development into three streams: product development as *rational plan*, *communication web*, and *disciplined problem solving*. By the empirical literature on product development, we mean articles published in major English-language organizations-oriented North American and European journals where this work is likely to appear¹ and a few, unpublished studies. We specifically focus on normative empirical studies of product development in which the development project is the unit of analysis. Even with these constraints, it is still impossible to cover all studies in one review article. As we built the literature review, we selected studies based on the rigor of their empirical methods and the degree to which they were cited by others. We allowed the network of studies to grow forward and backward in time with no constraints. As a cross-check against the burgeoning network of citations, we iteratively returned to the journals. Through this process, the three distinct networks of research that we describe and the temporal boundaries between 1969 and the present emerged.

¹ We included *Administrative Science Quarterly*, *Academy of Management Review*, *Organization Science*, *Organizational Studies*, *Journal of Management Studies*, *Harvard Business Review*, *California Management Review*, *Research Policy*, and *Journal of Product Innovation Management*.

Second, we synthesize these research findings into a model of factors affecting the success of product development (see Figure 1). This model integrates the common findings of the research streams and blends in complementary ones. In addition, the model attempts to build a theoretical framework for the findings in these streams.

Third, we indicate potential paths for future research. These paths are centered on the effects that the development process and product concept have on product success, patterns of organizing product-development work, strategic management, and customer/supplier involvement. Overall, the intent of the article is to contribute an understanding of the past literature, a model of current thinking, and a sense of future directions.

LITERATURE REVIEW

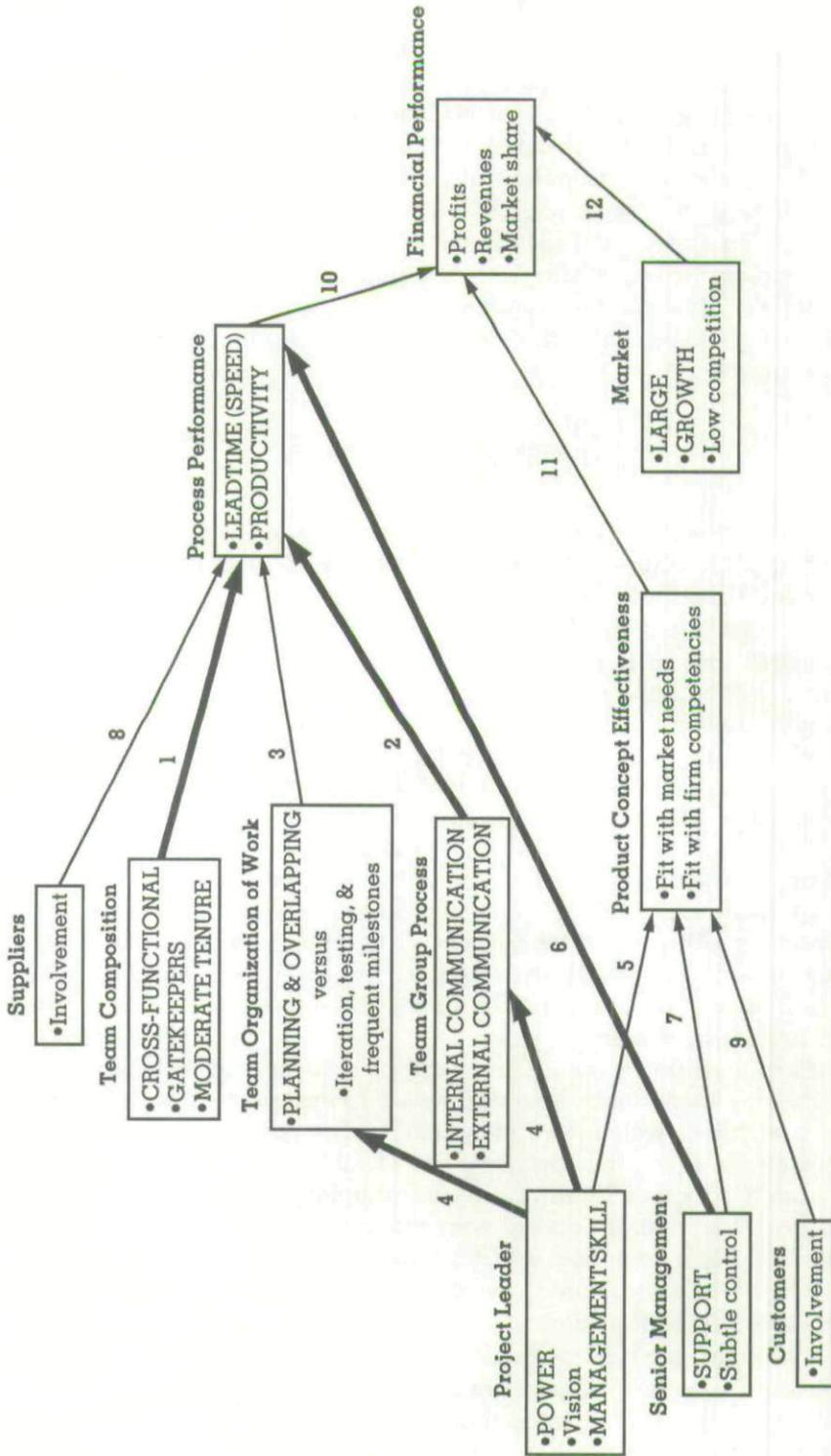
The product-development literature is vast, ranging from broad-brush explorations to in-depth case studies and across many types of products, firms, and industries. In this section, we create an organizing template for this work. Although several templates are possible, we have organized this one around three emergent research streams: rational plan, communication web, and disciplined problem solving. The three streams are summarized along key dimensions in Table 1.

We shaped our review around these streams because each involves a pattern of cumulative citations evolving from one or two pioneering studies. The rational stream builds on the Myers and Marquis (1969) and SAPPHO studies (Rothwell, 1972; Rothwell et al., 1974); the communication stream, on the early work of Allen at the Massachusetts Institute of Technology (MIT) (1971, 1977); and the problem-solving stream, on Imai and colleagues' (1985) study of successful Japanese products. Each stream's focus reflects an evolution based on the constructs highlighted in the pioneering works. The result has been three relatively coherent and distinct bodies of research.

Further, although there are overlaps in focus across the streams (e.g., all streams investigate how different players, processes, and structures affect performance), research within each stream centers on particular aspects of product development. The rational plan research focuses on a very broad range of determinants of *financial performance* of the product, whereas the communication web work concerns the narrow effects of *communication* on project performance. Disciplined problem solving centers on the effects of product—a development team, its suppliers, and leaders on the actual *product-development process*.

Moreover, the research within each stream is theoretically and methodologically similar. The rational plan perspective is primarily exploratory and atheoretical and, thus, helps to broadly define the relevant factors for product-development research. The communication web

FIGURE 1
Factors Affecting the Success of Product-Development Projects^a



^a Capital letters and thickened lines indicate robust findings.

TABLE 1
Comparison of Three Research Streams

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Concepts	Rational Plan	Communication Web	Disciplined Problem Solving
Key idea	Success via superior product, attractive market, rational organization	Success via internal and external communication	Success via problem solving with discipline
Theory	Mostly atheoretical	Information and resource dependence	Information including problem solving
Methods	Bivariate analysis; single informant; many independent variables	Deductive and inductive; multivariate; multiple informants	Progression from inductive to deductive; multiple informants; single industry, global studies
Product	Product advantage—cost, quality, uniqueness, fit with core competence	—	Product integrity—product vision that fits with customers and firm
Market	Size, growth, competition	—	—
Senior management	Support	—	Subtle control
Project team	X-functional, skilled	—	X-functional
Communication	High cross-functional	High internal, high external—various types and means	High internal
Organization of work	Planning and "effective" execution	—	Overlapped phases, testing, iterations, and planning
Project leaders	—	Politician and small group manager	Heavyweight leader
Customers	Early involvement	—	—
Suppliers	Early involvement	—	High involvement
Performance (dependent variable)	Financial success (profits, sales, market share)	Perceptual success (team and management ratings)	Operational success (speed, productivity)

stream complements this atheoretical view by relying on information-processing and resource dependence theoretical perspectives in the context of traditional research studies. The disciplined problem-solving stream takes the theoretical perspective of information processing one

step further to problem-solving strategies, using a progression from inductive to deductive research and an emphasis on global industry studies.

Overall, these three streams seem, to us, to capture best the cumulative patterns of product-development research. In this section, we outline these streams, including their key concepts, critical findings, underlying theory, methods, strengths, and weaknesses. However, as noted, although these streams are coherent bodies of work, they also complement and somewhat overlap one another. So, in the subsequent section, we emphasize these overlaps and complementarities by blending them into an integrative model of product development.

Product Development as Rational Plan

This rational plan perspective emphasizes that successful product development is the result of (a) careful planning of a superior product for an attractive market and (b) the execution of that plan by a competent and well-coordinated cross-functional team that operates with (c) the blessings of senior management. Simply put, a product that is well planned, implemented, and appropriately supported will be a success.

The focus in this stream is on discovering which of many independent variables are correlated with the financial success of a product-development project. The studies often are exploratory, and their perspective is broad. Typically, researchers gather questionnaires or possibly interview responses from well-placed, single informants. Informants usually are asked to explain why a product succeeded or failed, using a wide spectrum of internal and external factors. However, because results are often empirically observed correlations with success, the theoretical understanding of relationships usually is quite limited, and nonsignificant findings often are not reported. Selected studies in this stream are summarized in Table 2, and a model is presented in Figure 2.

The earliest work in this stream emphasized the importance of market issues over purely technical ones for successful product development. For example, Myers and Marquis (1969) studied the development of 567 successful products and processes in over 100 firms and 5 industries. Their principal result was that market pull (i.e., identifying and understanding users' needs) was substantially more important to the success of the products than technology push, and thus a cross-functional view was a key component of product success.

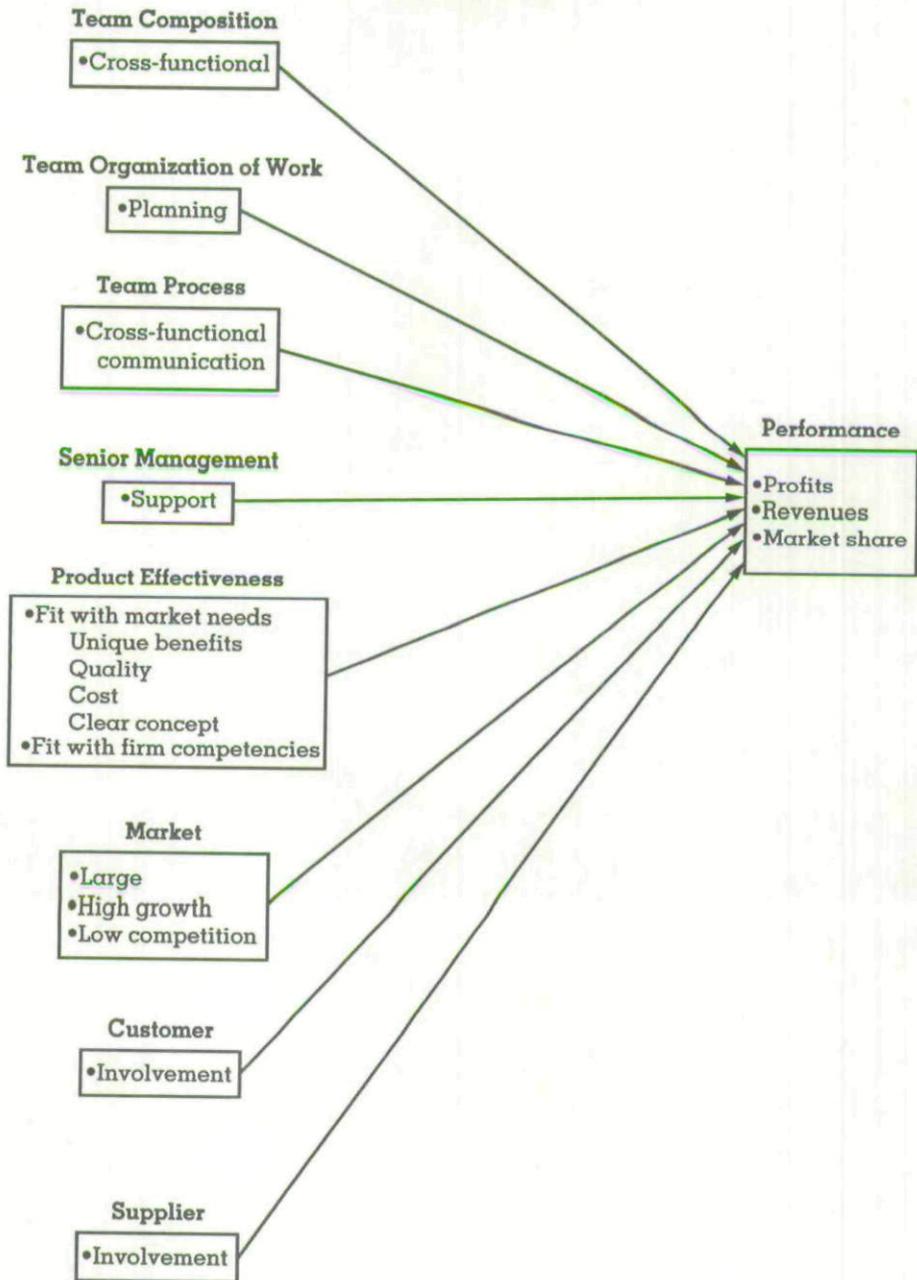
Later studies added failures to the mix (e.g., Rothwell, 1972; Rubenstein, Chakrabarti, O'Keefe, Souder, & Young, 1976). The SAPHO studies (e.g., Rothwell, 1972; Rothwell et al., 1974) were conducted using 43 success and failure pairs among chemical and instruments firms within the United Kingdom. The authors found that 41 factors, including understanding users' needs, attention to the market, efficient development, and senior leadership, were significantly related to successful product develop-

TABLE 2
Rational Plan Perspective: Selected Studies

Study	Sample	Context	Performance Measure (dependent variables)	Key Results (independent variables)
Myers & Marquis (1969)	567 successful product & process developments	121 U.K. construction, railroad, & computer firms	Product revenue or savings in production costs	Market: Market pull most important Communication: X-functional
SAPPHO (Rothwell, 1972; Rothwell et al., 1974)	43 success/failure product pairs	UK chemical & instrument firms ^a	Profitability & market share of product	Market: Understand user needs Senior Management: Involved
New Product (Cooper, 1979)	102 successful & 93 failed products	103 Canadian industrial firms	Profitability of product	Product: Unique or superior in customer's eyes Market: High growth, not competitive, unsatisfied customers Communication: Have synergy across different functions
Cooper & Kleinschmidt (1987)	123 successful & 80 failed products	125 Canadian manufacturing firms	11 financial measures, including profitability, market share, relative revenues	Product: Clear concept, better because of cost or quality or uniqueness Market: Attractive in size and growth potential Communication: Have synergy across different functions Senior management: Supportive Organization of work: Predevelopment planning
Stanford Innovation Project (Maidique & Zirger, 1984, 1985; Zirger & Maidique, 1990)	86 success/failure product pairs	86 U.S. Fortune 1,000 electronics firms	Profitability of product	Product: Synergy with competencies, better because of cost or quality or uniqueness Market: Large and growing Communication: High internal communication in X-functional teams Senior management: Supportive

^a Number of firms was not reported.

FIGURE 2
Rational Plan Model of Product Development



ment. Although the large number of factors makes it difficult to hone precise managerial and theoretical implications, this breadth of findings yields a comprehensive view of the important issues within product development. The SAPPHO studies were then followed by similar studies in other countries such as Finland (Kulvik, 1977), Hungary (Szakasits, 1974), and West Germany (Gerstenfeld, 1976).

Subsequent research sharpened the emergent emphases on product advantages, market attractiveness, and internal organization. Particularly important were two studies by Cooper (1979; Cooper & Kleinschmidt, 1987). The first, the NewProd study (Cooper, 1979), examined 102 successful and 93 failed products within 103 industrial firms in Canada. A subsequent study by Cooper and Kleinschmidt (1987) examined hypotheses from the NewProd and other studies using 203 products in 125 manufacturing firms, including 123 successes and 80 failures. Data were gathered from either the most knowledgeable manager or managers using a structured interview questionnaire. Success and failure were measured by 11 mostly financial measures, including profitability, payback, sales, and market share.

The authors observed that the most important determinant of product success was product advantage. The intrinsic value of the product, including unique benefits to customers, high quality, attractive cost, and innovative features, was the critical success factor. Such products were seen as superior to competing products and solved problems that customers faced.

Internal organization also was critical to product success. Particularly important was predevelopment planning. This included developing a well-defined target market, product specifications, clear product concept, and extensive preliminary market and technical assessments. Other internal organization factors also were important, including cross-functional skills and their synergies with existing firm competencies. Top management support also was important, but less so than these other factors.

Finally, market conditions also affected product success. Cooper and Kleinschmidt (1987) found that products that entered large and growing markets were more likely to be successful. In addition, products introduced into markets with low overall intensity of competition were more successful. However, they also noted that market characteristics were less important to commercial success than were product and internal organization factors such as product advantage, clear product concept, and predevelopment planning.

More recently, Cooper and Kleinschmidt (1993) conducted another NewProd study of product development in the North American and European chemical industries. The authors replicated some of their earlier findings. Most notably, they once again found that product advantage was most strongly associated with financially successful products. Contrary to their earlier study, the authors found in this case that market

competitiveness had no relationship with product success. These results suggest that the effect of market competitiveness on project outcomes needs further investigation.

The Stanford Innovation Project also emphasized product advantages, market attractiveness, and internal organization. Seventy product success/failure pairs initially were surveyed and, from these, 21 case studies were subsequently conducted (Maidique & Zirger, 1984, 1985). The third study expanded the first two by examining 86 success/failure product pairs (Zirger & Maidique, 1990). The data were gathered using a questionnaire that asked respondents to compare a product success with a product failure within their firms. Twenty-three items were examined using factor analysis and then 2-group discriminant analysis (Zirger & Maidique, 1990). The respondents were senior executives in the electronics industry who were attending an executive education program. Success was measured by whether executives considered the product to be a financial loss or a profit contributor. All hypotheses were supported.

The authors' conclusions read like a blueprint for a rationally planned product-development effort. First, excellent internal organization was important (i.e., smooth execution of all phases of the development process by well-coordinated functional groups). For example, the authors wrote, "Products are more likely to be successful if they are planned and implemented well" (Zirger & Maidique, 1990: 879). Products that had top management commitment and were built on existing corporate strengths were also likely to be successful. In addition, product factors were critical. Successful products provided superior customer value through enhanced technical performance, low cost, reliability, quality, or uniqueness. Finally, market factors also affected product success. Early entry into large, growing markets was more likely to lead to success.

More recently, other authors have identified specific aspects of rational planning, such as predevelopment planning (Dwyer & Mellor, 1991) and a focus on marketing and R&D involvement (Hise, O'Neal, Parsuraman, & McNeal, 1990), that correlate with product success. Another trend is to focus not on financial success but rather specifically on the speed of product development (e.g., Cordero, 1991; Mabert, Muth, & Schmenner, 1992). For example, Gupta and Wilemon (1990) focused on accelerating product-development pace. These authors polled 80 executives concerning factors that slowed or accelerated the development processes. Their suggestions for fast product development emphasized internal organization, including the importance of early cross-functional, customer, and supplier involvement in the process and visible top management support, more resources, and better teamwork (Gupta & Wilemon, 1990).

Overall, according to this stream of research, successful product development is the result of rational planning and execution. That is, successful products are more likely when the product has marketplace advantages, is targeted at an attractive market, and is well executed through excellent internal organization. Specifically, internal organiza-

tion is conceptualized as carefully planned predevelopment activities, execution by competent and well-coordinated cross-functional teams playing on the synergies of the firm, and significant support from top management.

This broad-brush approach leads to an excellent and a comprehensive overview of the product-development process, which emphasizes features of the product, internal organization, and the market. This same breadth, however, also somewhat undermines the contributions of the stream. To use a colloquialism, it is often difficult to observe the "new product development" forest amid myriad "results" trees. The findings of many studies read like a "fishing expedition"—too many variables and too much factor analysis. In this research stream, it is not uncommon for a study to report 10 to 20 to even 40 or 50 important findings (e.g., Hise et al., 1990; Rubenstein et al., 1976). Further, extensive bivariate analysis is commonplace, and this blurs possible multivariate relationships.

Second, the research stream relies heavily on retrospective sense making of complex past processes, usually by single informants. Individuals often are asked to quantify subjective judgments surrounding long lists of success and failure factors. The frequent use of single informants simply exacerbates these methodological problems. Thus, the research results are likely to suffer from a host of attributional and other biases, memory lapses, and myopia, which are associated with subjective, retrospective sense-making tasks.

Most important, the research in this stream often presents results without relying on well-defined constructs. Thus, is it surprising that better products are more likely to be successful or that well-executed processes are likely to produce more successful products? Rather, the next step is figuring out just what is a "better" product or just how do people go about the "effective" execution to develop such a product. Research in this stream is largely atheoretical as well, and so it fails to take the next theory-building step. For example, Zirger and Maidique (1990) found that entry into large, growing markets improves a project's performance. However, this result is not theoretically integrated with existing research that warns of first-mover disadvantages (Lieberman & Montgomery, 1988) or describes the power of imitation strategy (Bolton, 1993). Moreover, given their often exploratory nature, studies in this stream often do not report nonsignificant findings, which further inhibits theory building. Nonetheless, despite these shortcomings, this research stream has been enormously important, particularly in creating an early and a broad understanding of which factors are essential for successful product development and for emphasizing the role of the market in what is often conceived of as a purely technical or organizational task.

Product Development As Communication Web

A second stream of product-development research centers on communication. This research stream has evolved from the pioneering work of

Allen at MIT (1971, 1977). The underlying premise is that communication among project team members and with outsiders stimulates the performance of development teams. Thus, the better that members are connected with each other and with key outsiders, the more successful the development process will be.

In contrast to the first perspective, this stream is narrowly focused on one independent variable—communication. Thus, these studies emphasize *depth*, not *breadth* as in the rational plan, by looking inside the "black box" of the development team. They complement the rational lens by including political and information-processing aspects of product development. The result is excellent theoretical understanding of a narrow segment of the phenomenon. In this case, there also is greater methodological sophistication (e.g., multiple informants, multivariate analysis) than in the first stream. Selected studies in this stream are highlighted in Table 3, and a model is presented in Figure 3.

Some of the earliest empirical research along these lines was focused on the flow of information in R&D groups (e.g., Allen, 1971, 1977). Often the approach used was to have professionals keep track of their communications for some period of time. For example, Katz and Tushman (1981) studied the performance of project groups in the R&D facility of a large corporation. In 60 project groups, a total of 345 professionals kept track of their communications for a randomly chosen day each week for 15 weeks.

The results of these early studies highlight the importance of *external communication* to success. Specifically, these studies observed the presence of "gatekeepers"—(i.e., high-performing individuals who also communicated more often overall and with people outside their specialty) (Allen, 1971). These gatekeepers brought information into the organization and dispersed it to fellow team members. The authors noted that gatekeepers not only gathered and translated external information, but they also facilitated the external communication of their fellow team members (Katz & Tushman, 1981). Further, members of development projects with gatekeepers performed better than those without, even after accounting for the direct effect of the gatekeeper's high, personal performance. Teams with gatekeepers communicated more externally, leading to improved project performance (Katz & Tushman, 1981). Finally, Von Hippel (1986) noted how important communication with key customers was regarding better product designs.

Other authors have built on this early work by Allen and colleagues. For example, the content of external communication has been examined closely by Ancona and Caldwell (1990, 1992a,b). These authors collected questionnaires from 409 members of 45 new product-development teams in 5 companies on communication and success patterns. Success was measured by subjective team and management ratings of performance. The authors found that team members communicated more with outsiders who had similar functional backgrounds. Thus, when there were more functions represented on the team, there was more external communica-

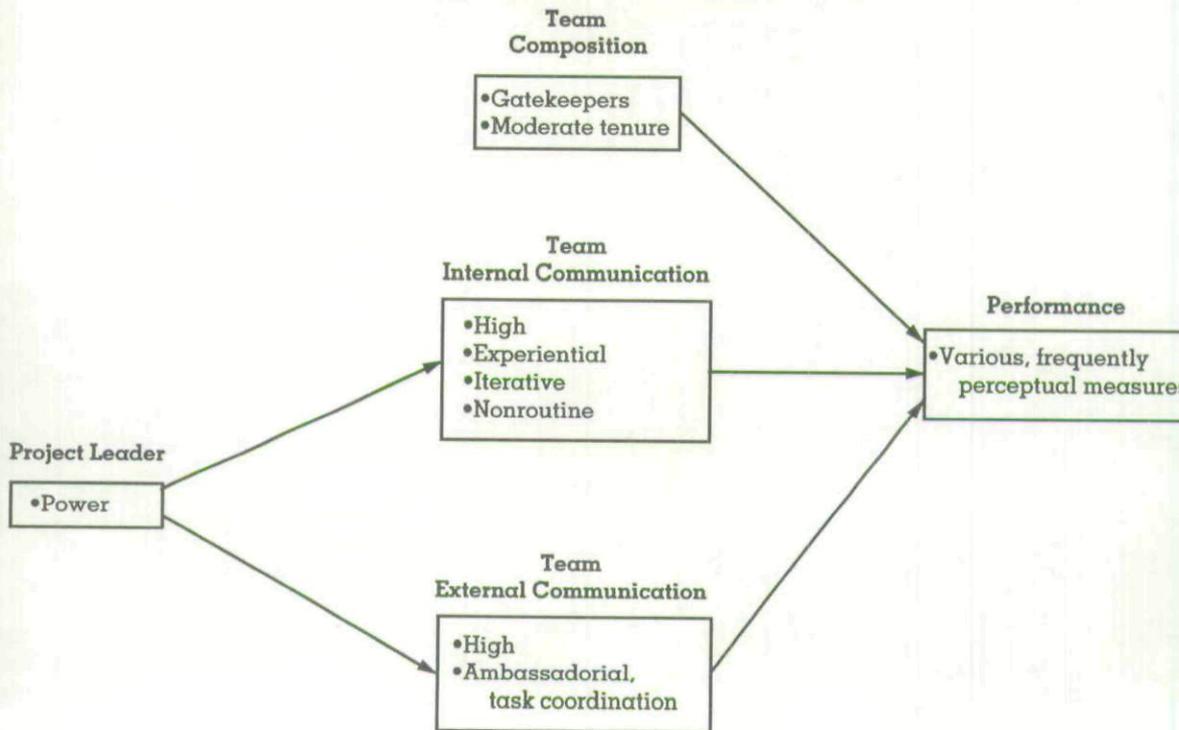
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TABLE 3
Communication Web Perspective Selected Studies

Study	Sample	Context	Performance Measure (dependent variables)	Key Results (independent variables)
Allen (1971, 1977) Katz & Tushman (1981)	R&D professionals i.e., 345 professionals in 60 projects (Katz & Tushman)	large U.S. R&D laboratories	Management rated overall technical performance of project	Communication: Technology gatekeeper, frequent external communication Project Leader: As politician
Katz (1982)	50 R&D project groups	1 large U.S. R&D laboratory	Team and management rated performance for overall team performance	Communication: Curvilinear relationship with group longevity, mediated by external communication
Katz & Allen (1985)	86 R&D project teams	9 technology-based major U.S. firms	Senior management rated team performance	Project Leader: Project manager as powerful small-group manager; functional manager as inward- & technology-focused leader
Keller (1986)	32 R&D project groups	1 large U.S. R&D organization	Team & management rated performance for quality, budget, schedule	Communication: Internal communication as group cohesiveness
Ancona & Caldwell (1990, 1992a, 1992b)	45 product-development teams	5 large high-tech firms ^a	Team and management rated performance for innovation, schedule, efficiency, budgets, and conflict	Communication: External communication combining ambassadorial and task coordination; internal communication as defined goals, workable plans, and prioritized work
Dougherty (1990, 1992) Dougherty & Corse (in press)	40 product-development projects	15 large high-tech firms (chemicals & computers/ communications) ^a	Failure (cancellation) & success as rated by management	Communication: Overcome "thought world" barriers through interactive and iterative communication, concrete experiences, and violating organizational routines

^a Geographic location of firms was not reported.

FIGURE 3
Communication Web Model of Product Development



tion by the team as a whole and better management-rated performance (Ancona & Caldwell, 1992a).

More important, the authors (Ancona & Caldwell, 1990) developed a typology of external communication or "boundary-spanning" behaviors. Ambassador activities consisted of political activities such as lobbying for support and resources as well as buffering the team from outside pressure and engaging in impression management. Task coordination involved coordination of technical or design issues. Scouting consisted of general scanning for useful information, whereas guard activities were those intended to avoid the external release of proprietary information.

Ancona and Caldwell (1992b) subsequently identified group-level strategies employed by the 45 product-development teams in their sample. One of this study's most interesting findings was that the frequency of external communications was not a significant predictor of team performance. Rather, communication strategy was germane. The most successful product-development teams engaged in a comprehensive external communication strategy, combining ambassador and task-coordination behaviors that helped these teams to secure resources, gain task-related information, and so enhance success. In contrast, less successful product-development teams used strategies involving fewer types of external

communication activities and less overall external communication. Thus, more effective teams engaged in both political and task-oriented external communications, suggesting that product-development teams must attend not only to the frequency of external communication, but also to the nature of that interaction (Ancona & Caldwell, 1992b). Work by Benjamin (1993) has led to similar conclusions regarding the importance of external political communication and impression management.

There also has been interest in *internal communication* among team members. For example, in his study of 32 project groups, Keller (1986) found that internal group cohesion helped performance. Similarly, Ancona and Caldwell (1992a) found that teams with more thorough internal communication (e.g., they defined goals better, developed workable plans, and prioritized work) had superior performance. Also, Joyce (1986) observed that powerful project leaders in matrix organizations often enhanced the quantity of internal communication but decreased its quality.

The critical cross-functional issues of internal communication have been explored by Dougherty (1990, 1992; Dougherty & Corse, In press). **This research consisted of a multiple case, inductive study of the barriers** that hinder cross-functional communication. The study examined 18 new product-development efforts in 5 firms. Failed products were those that were canceled after introduction. Successful products were those that were meeting or exceeding expectations after introduction. Later research (Dougherty & Corse, In press) extended the sample to 40 projects, 134 people, and 15 firms. A key feature is emphasis on innovative product development in large, established firms.

Dougherty (1990) demonstrated that various functional departments were tantamount to "thought worlds," each with its own "fund of knowledge"—what members know—and "system of meaning"—how members know (Dougherty, 1992). Not surprisingly, individuals from different departments understood different aspects of product development, and they understood these aspects in different ways. This difference led to varying interpretations, even of the same information. Interestingly, what distinguished successful projects was not the absence or presence of these barriers, but rather how they were overcome. For successful products, cross-functional personnel combined their perspectives in a highly interactive, iterative fashion (Dougherty, 1990). This type of internal communication appeared to increase information content. In contrast, failed products were characterized by sequential attention by functional groups such that each departmental view dominated a particular phase of the project.

Project teams also overcame cross-functional communication barriers when team members participated in concrete tasks together and violated routines such as usual relationships and divisions of tasks (e.g., Dougherty, 1992; Dougherty & Corse, In press). These tactics for organizing internal communication appeared to increase the information flow during the communication process. Dougherty (1992) described, for example, how

one team met with customers directly in focus groups to achieve a common team understanding of who the customer was. This common experience improved the information content of the communication as team members developed a common understanding of the customer while working together.

Finally, researchers also have been interested in how communication affects the performance of teams over time. For example, Katz (1982) explored the relationship among the mean tenure of a team, the degree of external communication, and performance. In his study of 50 product-development teams in a large American corporation, he found that initially group performance increased with increasing mean tenure of the group, but this relationship reversed and performance dropped off after five years. The decline in performance was significantly correlated with a decline in external communication.

In summary, the results indicate that *external communication* is critical to successful product development. However, this stream goes beyond this rather intuitive result to illustrate how teams increase their external communication and what types of communication are important. Specifically, successful product-development teams include gatekeepers, who encourage team communication outside of their groups, and powerful project managers, who communicate externally to ensure resources for the group. In addition, such teams also engage in extensive political and task-oriented external communication. The underlying rationale is that politically oriented external communication increases the resources of the team, whereas task-oriented external communication increases the amount and variety of information. These types of communication, in turn, aid the development-process performance.

Similarly, *internal communication* improves development-team performance. For example, managers who are inwardly focused on the technical issues of the project will enhance internal communication and improve team performance. Cross-functional teams that structure their *internal communication around concrete tasks, novel routines, and fluid job descriptions* also have been associated with improved internal communication and successful products. These observations on how to break down cross-functional barriers are particularly critical insights. Thus, high internal communication increases the amount and variety of internal information flow and, so, improves development-process performance.

Overall, two theoretical themes emerge in the literature. One, an information-processing view, emphasizes that frequent and appropriately structured task communication (both internal and external) leads to more comprehensive and varied information flow to team members and, thus, to higher performing development processes. The second, a resource dependence view, emphasizes that frequent political communication (typically external) leads to higher performing development processes by increasing the resources (e.g., budget, personnel, equipment) available to the team.

In contrast, the principal shortcoming of this perspective is that it is so focused on communication by project team members that other factors (e.g., organization of the work, product attributes, market attractiveness) are neglected. There are also other problems. For example, although this research is more methodologically sophisticated than the first stream (e.g., multiple informants, multivariate analysis, tighter constructs), performance measures frequently are very subjective, and so it is difficult to know whether the results would replicate for more objective measures of performance, such as product profitability. In addition, the research in this stream does not distinguish between different types of products, such as incremental versus breakthrough versus platform products. However, as Katz (1982) observed, such distinctions may affect appropriate types of communication.

Despite these problems, this research stream has been influential, particularly in highlighting the political and information-processing dynamics underlying the communication processes of successful product-development teams. Thus, the in-depth focus of the communication web complements the sweeping perspective of the rational plan.

Product Development as Disciplined Problem Solving

A third stream of research is what we have termed the *disciplined problem-solving* perspective. This stream evolved from studies of Japanese product-development practices in the mid-1980s (e.g., Imai et al., 1985; Quinn, 1985). In this case, successful product development is seen as a balancing act between relatively autonomous problem solving by the project team and the discipline of a heavyweight leader, strong top management, and an overarching product vision. The result is a fast, productive development process and a high-quality product concept. Selected studies are summarized in Table 4, and a corresponding model appears in Figure 4.

Case-based research (Imai et al., 1985; Quinn, 1985; Takeuchi & Nonaka, 1986) laid the groundwork for this stream of research. For example, Imai and colleagues (1985) studied seven successful product-development efforts in five different Japanese companies across several industries. The seven products included Fuji-Xerox's FX-3500 copier, the City box-car by Honda, and the Canon Auto Boy (Sure Shot) camera. Performance was defined in terms of speed and flexibility of development.

The authors found several management practices that were particularly effective for fast, efficient product development. One was the extensive use of supplier networks. The researchers observed that strong formal ties to suppliers and R&D networks were very important to the product-development process. In such networks, suppliers can acquire a very high level of technical skill in a specialized area, which allows them to fulfill sudden or unusual requests quickly and effectively.

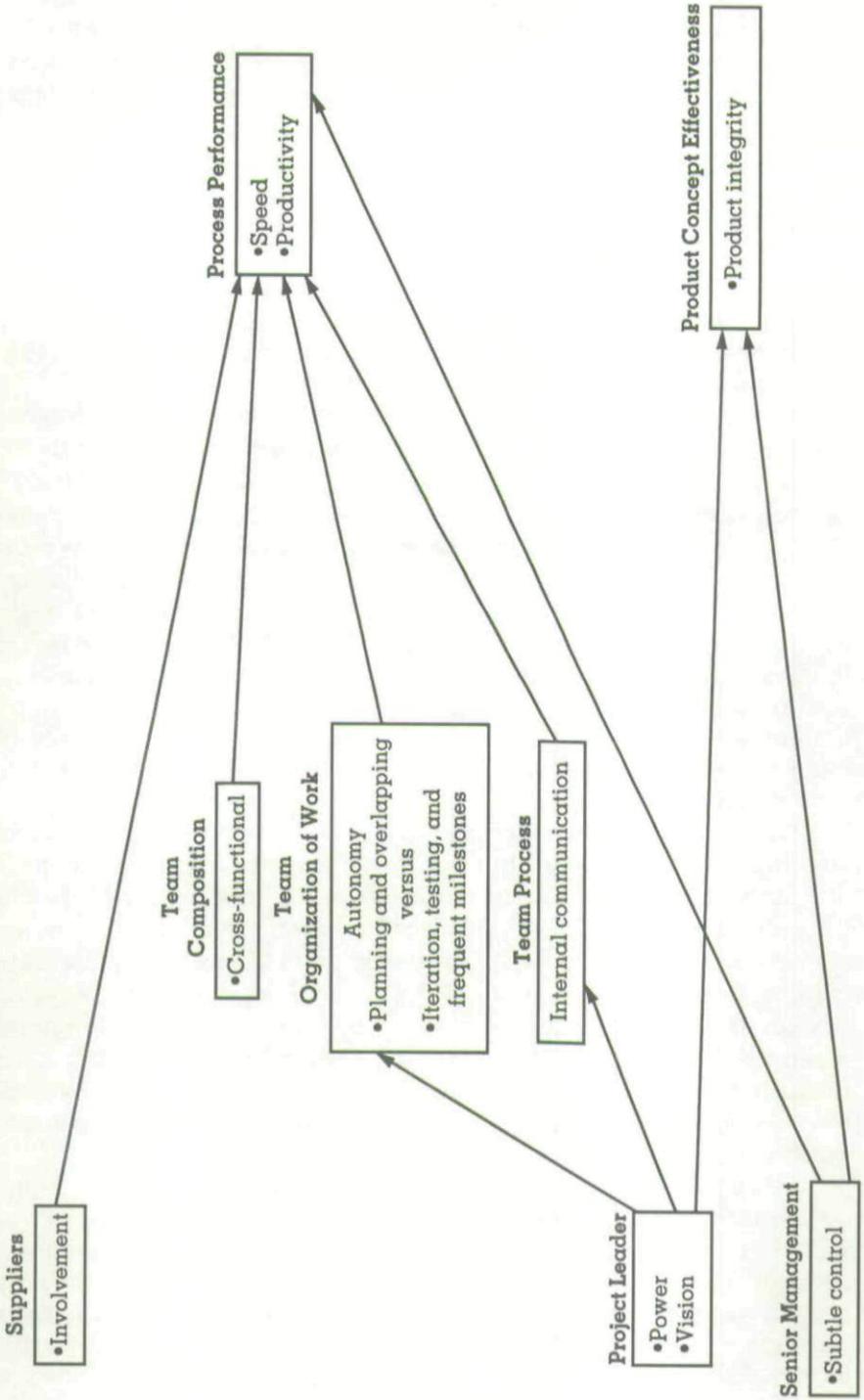
Imai and colleagues (1985) also observed a problem-solving strategy involving cross-functional development teams that aided effective

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TABLE 4
Disciplined Problem Solving: Selected Studies

Study	Sample	Context	Performance Measure (dependent variables)	Key Results (independent variables)
Imai et al. (1985) Takeuchi & Nonaka (1986)	7 successful development projects	5 Japanese companies	Speed, flexibility	Senior management: Subtle control High internal team communication, multilevel learning Communication: Organization of work: Cross-functional teams, overlapping phases High involvement Suppliers: High involvement
Harvard Auto Study (Clark, Chew, & Fujimoto, 1987; Clark & Fujimoto, 1991; Hayes et al., 1988)	29 development projects	20 firms in the auto industry—U.S., Japan, and Europe	Quality, speed, productivity	Product: Product integrity High internal team communication Communication: Organization of work: Cross-functional teams, overlapping phases, predevelopment planning Project leader: Heavyweight project manager High involvement Supplier: High involvement
MIT Auto Study (Womack et al., 1990)	Same as Harvard study plus consolidated data from other sources	Same as Harvard study	Operational variables, including quality, speed, productivity	Communication: High internal team communication Organization of work: Cross-functional teams, overlapping phases, predevelopment planning
Iansiti (1992, 1993)	27 development projects	Firms in mainframe computer industry—U.S., Europe, Japan ^a	Speed, productivity	Product: Product integrity Organization of work: Predevelopment planning
Eisenhardt & Tabrizi (In press)	72 development projects	36 Asian, U.S., & European computer firms	Speed	Organization of work: Cross-functional teams, iterative prototype and test process, limited planning and use of CAD, don't reward for schedule

^a Number of firms was not reported.

FIGURE 4
Disciplined Problem-Solving Model of Product Development



product development. When the development team was composed of members with varied functional specializations, team members had access to more diverse information. In addition, cross-functional teams permitted the overlap of development phases, which also quickened the pace of product development. Furthermore, the authors observed that product development was accelerated by overlapping of development phases and cross-functional teams only if supported by continuous communication among project members. This communication increased the information flow among team members, making it easier for team members to understand each other's specialties and to coordinate overlapped development phases. The creation of redundant information (Nonaka, 1990) and an emphasis on extensive multifunctional training (Imai et al., 1985) also were related to this style of problem solving.

Finally, Imai and colleagues (1985) noted that rather than playing just a supportive role, as suggested by the rational plan studies (e.g., Cooper & Kleinschmidt, 1987; Gupta & Wilemon, 1990; Zirger & Maidique, 1990), senior management should engage in "subtle control." The key idea behind subtle control is that members of successful project teams maintain a balance between allowing ambiguity, such that creative problem solving can flourish at the project team level, and exercising sufficient control, such that the resulting product fits with overall corporate competencies and strategy. The authors found that, for the best performance results, senior management engaged in subtle control by communicating a clear vision of objectives to their teams while simultaneously giving team members the freedom to work autonomously within the discipline of that vision.

Later research replicated and extended this early work. For example, several Harvard researchers studied the management of product-development projects in the auto industry (Clark et al., 1987; Clark & Fujimoto, 1991; Hayes, Wheelwright, & Clark, 1988). These very impressive data consist of in-depth case studies of 29 major car-development projects across 20 companies—3 American, 8 Japanese, and 9 European. Similar to the aforementioned study by Imai and his colleagues, this research examined new models of established products, not breakthrough products. This auto industry data measured the performance of the product-development process along three dimensions: total product quality, lead time, and productivity.

The authors (e.g., Clark et al., 1987; Clark & Fujimoto, 1991) replicated earlier findings. They reported that extensive supplier networks coupled with overlapping product-development phases, communication, and cross-functional groups (what they term *integrated problem solving*) improved the performance of development teams. The authors also introduced two central concepts: heavyweight team leaders and product integrity. These two concepts help to clarify the meaning of subtle control.

"Heavyweight" team leaders are powerful "linking pins" who, on the one hand, coordinate the activities of a product-development team and,

on the other hand, work with senior management to create an overarching product concept. Thus, senior management can exercise subtle control through the use of such leaders who manage their teams in the context of a product vision. The findings indicate that these team leaders are able to gain resources, command respect, and break down traditional functional allegiances while simultaneously building a strong product vision (Clark et al., 1987; Clark & Fujimoto, 1991; Hayes et al., 1988).

"Product integrity" (Clark & Fujimoto, 1991), unlike the dimensions of product attractiveness in the rational plan perspective such as low price, describes the notion of a product's being consistent with the corporate image. Product integrity implies a clear vision of the product's intended image, performance, and fit with corporate competencies and customers. By focusing on establishing product integrity, senior management can ensure that an overall vision for the product is communicated to the project team and, thus, balance the autonomy gained through heavyweight leadership.

Finally, this study also added an emphasis on predevelopment activities. Hayes and others (1988) described how bringing conflicts to the surface early in the development process was an important factor in successful development projects. By resolving conflicts through mutual accommodation at low levels in the organizational hierarchy, a clear project vision was established early on, which subsequently sped up the development process.

A study related to the Harvard auto industry research, the MIT International Motor Vehicle Program, examined lean versus mass production in the auto industry. This study (Womack, Jones, & Roos, 1990) presented Clark and Fujimoto's (1991) data along with some consolidated data from secondary sources. Not surprisingly, many of their conclusions, such as the importance of powerful leaders, overlapping development phases, predevelopment activity, and internal communication to product development, replicated those of the Harvard study (Clark et al., 1987; Clark & Fujimoto, 1991; Hayes et al., 1988).

More recent research in this stream emphasized industries with less domination by Japanese competitors and more scientific content. For example, Iansiti (1992, 1993) deductively examined the mainframe computer industry. His data consisted of 27 in-depth studies that represent all the major products developed by the 12 chief competitors in the mainframe computer industry (from Japan, the United States, and Europe) during the 1980s. The author focused on the development of technologies associated with the packaging and interconnect system of the mainframe processor.

The primary result is that a high system focus (i.e., a combination of technical integration, exposure to systems integration, and accumulation of interaction knowledge) predicted both lead time and productivity. Similar to product integrity, system focus implied concern for how technology choices for a given component fit with the product as a whole. Like predevelopment activities, system focus also involved early planning for the

integration of new technology, product expectations, and manufacturing systems into the problem-solving process. Thus, this result strengthened earlier findings that predevelopment planning and product integrity enhanced the performance of product-development teams.

A study by Eisenhardt and Tabrizi (In press) examined the computer industry in Japan, Europe, and the United States. This deductive study considered 72 products in 36 firms, including the personal, workstation, mainframe, and peripherals segments of the industry. Thus, the average product life cycle was substantially shorter than in the mainframe computer or automobile industry studies. The data were collected on site using research teams who helped firm personnel gather data. The focus was on speed of development as the performance measure. Specifically, the authors compared a compression model of fast product development with an experiential approach.

The unique insight of this study is that fast product development was associated with the experiential approach (Eisenhardt & Tabrizi, In press). Product teams who engaged in more experiential or improvisational product design through frequent iterations, more testing, frequent milestones, and powerful leadership developed products more quickly. In contrast, attempts simply to compress the product-development cycle through the use of computer-aided design (CAD), rewards for schedule attainment, supplier involvement, overlapping development stages, or extensive planning not only did not accelerate pace, but, in fact, often slowed it. The exception was the mainframe segment in which the use of CAD, supplier involvement, and overlap effectively accelerated the pace. Thus, these results suggest that there are two relevant problem-solving models for organizing product development. One focuses on factors such as planning and overlap that are relevant for more stable products in mature settings (e.g., Clark & Fujimoto, 1991; Iansiti, 1992), and the other focuses on experiential product design that is relevant for less predictable products in uncertain settings, such as personal computers, workstations, and peripherals. Finally, as in the previous research, cross-functional teams sped up development for all industry segments.

In summary, this stream of research envisions successful product development as disciplined problem solving. That is, successful product development involves relatively autonomous *problem solving* by cross-functional teams with high communication and the organization of work according to the demands of the development task. This perspective also highlights the role of project leaders and senior management in giving problem solving a *discipline*—a product vision. There is an emphasis on both project and senior management, on the one hand, to provide a vision or discipline to the development efforts and yet, on the other hand, to provide autonomy to the team. Thus, this stream portrays product development as a *balancing act* between product vision developed at the executive level and problem solving found at the project level.

In contrast to the rational plan stream, this stream is more specific

about the effective organization of work and is more focused on the development process and product concept than on the financial success of the product. In contrast to the communication web perspective, this stream has a broader scope and considers the role of suppliers and senior management in addition to project leaders and teams. Methodologically, the data are much richer and more detailed than the single-informant information that underlies much of the rational stream. Theoretically, this perspective extends the information-processing view of the communication web research by emphasizing not only the amount and variety of information, but also its organization into problem-solving strategies.

However, the stream suffers from several shortcomings. One is that there is a lack of political and psychological realism. In comparison with the communication web, there is naive understanding of the political realities of product development, such as the dependence of project teams on external actors for resources. From a psychological standpoint, there is little appreciation of the problems of actually motivating people and making cross-functional teams, high communication, and overlapping work. Moreover, the heavyweight leaders seem almost "superhuman" in their skills and duties.

Second, some of the constructs are challenging to comprehend. For example, subtle control, product vision, and system focus are vague concepts. Even with attempts at clarification (e.g., Clark & Fujimoto, 1990; Clark & Wheelwright, 1992), product integrity and heavyweight project leader concepts also remain hazy. Although this lack of clarity may reflect the complexity of the subject (or perhaps the often non-Western origin of the ideas), it also impairs the usefulness of the perspective.

Finally, there is an extensive reliance on a Japanese viewpoint. Even though Japanese comparisons have been critical to improving thinking, Japanese industrial dominance sometimes makes it unclear which features are important to product development and which are simply Japanese. This concern seems particularly relevant to the supplier network findings (e.g., Clark & Fujimoto, 1991; Imai et al., 1985), which are dependent on the specifics of the Japanese industrial infrastructure. Nonetheless, the image of product development as disciplined problem solving is a powerful and sophisticated metaphor for successful product development.

TOWARD AN INTEGRATIVE MODEL OF PRODUCT DEVELOPMENT

In the previous section, we described three streams of product-development research. These streams evolved from different sources and focused on somewhat different aspects of product development. However, as we observed previously, they also offer complementary and sometimes overlapping insights into product development. In this section, we rely on these insights to provide the basis of an integrative model.

Key to developing this model is the observation that the three streams focus on both overlapping and complementary sets of constructs. The

rational plan perspective contributes a sweeping view of product development, including team, senior management, market, and product characteristics to predict financial success. In contrast, the problem-solving perspective has a more deeply focused view on the actual development process (i.e., those project team and management factors that contribute to a better product-development process and a more effective product concept). The concepts are more elaborated than in the rational plan perspective so that, for example, the "effective execution" of the rational plan is given more concrete and detailed development in the problem-solving perspective. The communication web perspective is narrower still. This research centers on a very specific, although important, aspect of product development, namely on internal and external communication by project team members.

Also key to developing an integrative model is the observation that the streams have complementary theoretical approaches. The rational plan perspective is largely atheoretical, consisting of collections of associations. In contrast, the product-solving perspective has a cognitive theoretical orientation, which links ideas about information and its organization to effective problem solving. Finally, the communication perspective relies on a simpler but consistent theoretical view of information (i.e., the amount and variety of information) and a complementary political perspective, which emphasizes the need for resources.

These overlapping and complementary focal interests as well as the theoretical complementarities suggest that the streams are ready for synthesis into an integrative model. In this section, we craft such an integrated conceptual perspective that summarizes key findings within the literature and provides a departure point for future studies of product development. The resulting model is depicted in Figure 1.

Model Overview

The organizing idea behind the model in Figure 1 is that there are multiple players whose actions influence product performance. Specifically, we argue that (a) the project team, leader, senior management, and suppliers affect *process performance* (i.e., speed and productivity of product development), (b) the project leader, customers, and senior management affect *product effectiveness* (i.e., the fit of the product with firm competencies and market needs), and (c) the combination of an efficient process, effective product, and munificent market shapes the *financial success* of the product (i.e., revenue, profitability, and market share).

Underlying these relationships are the theoretical underpinnings that we have identified from the combined research streams. Thus, process performance is driven by the amount, variety, and problem-solving organization of information and by the resources available to the team. Product effectiveness is driven by the input of leaders, senior management, and customers into the formation of a clear product vision (a less well-understood process). Both product effectiveness and process performance

influence the financial success of the product. We turn now to a description of the model, arranged according to the key players.

Project Team

The heart of the product-development process and the focus of much research is the project team. Project team members are the people who actually do the work of product development. They are the people who transform vague ideas, concepts, and product specifications into the design of new products. Not surprisingly, then, the project team is central to our model of product development. Specifically, we argue that the *composition, group process, and work organization* of the project team affect the information, resources, and problem-solving style of the team. These, in turn, ultimately influence process performance (i.e., speed and productivity of the process) (Figure 1).

Regarding composition, consistent with all three streams, *cross-functional teams* are critical to process performance (e.g., Clark & Fujimoto, 1991; Dougherty, 1992; Zirger & Maidique, 1990). We define *cross-functional teams* as those project groups with members from more than one functional area such as engineering, manufacturing, or marketing. The underlying reasoning is that the functional diversity of these teams increases the amount and variety of information available to design products. This increased information helps project team members to understand the design process more quickly and fully from a variety of perspectives, and thus it improves design process performance. Moreover, the increased information helps the team to catch downstream problems such as manufacturing difficulties or market mismatches before they happen, when these problems are generally smaller and easier to fix. Thus, consistent with the empirical support in all three research streams, cross-functional teams are associated with high-performing processes. Moreover, this link (1) in the model is among the most important and empirically robust (e.g., Clark & Fujimoto, 1991; Dougherty, 1992; Zirger & Maidique, 1990).

Gatekeepers are another important facet of project team composition. Gatekeepers are individuals who frequently obtain information external to the group and then share it within the project team. Similar to cross-functional teams, they affect process performance by increasing the amount and variety of information available in the design process. Gatekeepers expose the project team members to more and diverse information such as new technical developments occurring outside the group. Although gatekeepers are probably less important in cross-functional teams because the members of such teams have natural outside contacts in their functional homes, gatekeepers clearly increase the external information reaching the project team (link 1 in the model) (Allen, 1971, 1977; Katz & Tushman, 1981).

Finally, *team tenure* is a third composition factor that plays a role in influencing process performance. Teams with a short history together

tend to lack effective patterns of information sharing and working together (Katz, 1982). Thus, the amount and variety of information that can be communicated among project team members is limited by this unfamiliarity. In contrast, teams with a long tenure together tend to become inward focused and neglect external communication (Katz, 1982). This tendency restricts the information and resources from outside the team that the team members receive. Because neither of these situations is desirable, process performance is highest when team tenure is at moderate levels. At this level of tenure, team members are most likely to engage in both extensive internal and external communication and, therefore, to receive maximum benefit. As Katz found (1982), this leads to higher project performance (link 1 in the model).

Another important factor affecting process performance is group process, especially communication. Results from all three research streams indicate that effective group processes, particularly those related to communication, increase information and so are essential for high-performing development processes (e.g., Imai et al., 1985; Katz, 1982; Zirger & Maidique, 1990). In the case of *internal communication* (e.g., Dougherty, 1990; Keller, 1986), frequent communication increases the amount of information directly in that more communication usually yields more information. More subtly, frequent communication also builds team cohesion, which then breaks down barriers to communication and so increases the amount of information as well (Keller, 1986). Moreover, especially when this communication is effectively structured (e.g., includes concrete communication surrounding shared group experiences and non-routine rule breaking [Dougherty, 1992]), it cuts misunderstandings and barriers to interchange so that the amount of information conveyed is increased. This, in turn, improves the speed and productivity of the entire development process (Dougherty, 1992).

In the case of *external communication*, frequent communication with outsiders such as customers, suppliers, and other organizational personnel opens the project team up to new information (e.g., Clark & Fujimoto, 1991; Imai et al., 1985; Katz, 1982; Katz & Tushman, 1981). When this external communication is task oriented, team members gain information from diverse viewpoints beyond those of the team. Further, when the communication is frequent, project teams are likely to develop an absorptive capacity such that they become more efficient in gaining and using the information being conveyed. Both of these factors should improve the productivity and pace of the development process. Also important is external communication in the form of political activities such as lobbying for resources, engaging in impression management, and seeking senior management support for the project (Ancona & Caldwell, 1992b). Taken together and consistent with previous research, internal and external communication both increase the amount and variety of information and the resources available to the project team. These, in turn, improve process performance. These links (link 2 in the model) are also among the

most empirically robust (e.g., Ancona & Caldwell, 1992b; Clark & Fujimoto, 1991; Imai et al., 1985; Katz, 1982; Katz & Allen, 1985; Katz & Tushman, 1981).

The third team feature of the model is the problem-solving strategy by which team members organize their work. As described in the problem-solving stream, several empirical findings suggest a contingent set of problem-solving strategies that are appropriate for different types of tasks (Eisenhardt & Tabrizi, In press). Each strategy represents a different structuring of information. For stable and relatively mature products such as automobiles (Hayes et al., 1988; Womack et al., 1990) and mainframe computers (Eisenhardt & Tabrizi, In press; Iansiti, 1992), product development is a complex task for which tactics such as *extensive planning* and *overlapped development stages* are appropriate. These tactics assume a certain but often complex problem-solving task that can be rationalized. For example, consistent with the rational and problem-solving perspectives, planning (e.g., Cooper & Kleinschmidt, 1987; Hayes et al., 1988; Iansiti, 1992; Zirger & Maidique, 1990) improves the speed and productivity of the development process by eliminating extra work, rationalizing and properly ordering the steps of the process, and avoiding errors. Similarly, overlapped development stages improve process performance (Clark & Fujimoto, 1991; Imai et al., 1985) by allowing at least partially simultaneous execution of development steps such as design and test, which often are viewed as sequential. In effect, the development process is squeezed together (e.g., Clark & Fujimoto, 1991).

In contrast, when there is more uncertainty in the design process, such as in rapidly changing industries (e.g., microcomputers), more experiential tactics, including *frequent iterations* of product designs, *extensive testing* of those designs, and *short milestones* (i.e., short time between successive milestones) improve process performance (e.g., Eisenhardt & Tabrizi, In press). The underlying idea is that under conditions of uncertainty it is not helpful to plan. Rather, maintaining flexibility and learning quickly through improvisation and experience yield effective process performance (e.g., Eisenhardt & Tabrizi, In press; Miner & Moorman, 1993; Weick, 1993). However, although these ideas may be attractive, they have not been examined extensively, and the contingencies between these factors and the previously mentioned factors of overlap and planning have not been well explored empirically (link 3 in the model). As we will discuss, further elaboration and testing of this part of the model are prime opportunities for future research.

Project Leader

Even though the cross-functional team is the heart of efficient product development, the project leader is the pivotal figure in the development process. Consistent with the communication and problem-solving perspectives, the project leader is the linking pin or bridge between the project team and senior management. Therefore, as indicated in Figure 1,

the project leader critically affects both the process performance (i.e., speed and productivity of the development process) and the effectiveness of the product (e.g., Clark & Fujimoto, 1991; Joyce, 1986; Katz & Allen, 1985). Several characteristics of the project team leader are particularly germane.

One central characteristic is the power of the project leader. By powerful leaders we mean those project leaders with significant decision-making responsibility, organizationwide authority, and high hierarchical level. Such leaders are particularly able to improve process performance. The underlying rationale is that such leaders are highly effective in obtaining resources such as more personnel and larger budgets for the project team. As Ancona and Caldwell (1992b) observed, powerful project leaders are particularly effective politicians in lobbying for resources, protecting the group from outside interference, and managing the impressions of outsiders. In contrast, less powerful project leaders are likely to be less successful in gaining needed talent and financial support and in shielding the team from outside interference. In addition, powerful leaders also may command greater respect and, thus, may be able to attract better project team members to the group and to keep groups focused and motivated (Clark & Fujimoto, 1991). These qualities, in turn, create a faster and more productive development process. Moreover, because the importance of a powerful leader has been demonstrated in both the communication and problem-solving streams (e.g., Clark & Fujimoto, 1991; Katz & Allen, 1985) (link 4 in the model), it is a robust link.

A second, important characteristic of the project leader is *vision*. Vision involves the cognitive ability to mesh a variety of factors together to create an effective, holistic view and to communicate it to others. Specifically, in the case of product development, this means meshing together firm competencies (e.g., particular technical, marketing, or other skills) and strategies with the needs of the market (e.g., consumer preferences for style and cost) to create an effective product concept. As described in the problem-solving perspective, this is a critical characteristic of project leaders because they often are central to the creation of the product concept. Project leaders, together with senior management, frequently shape the overall product concept and communicate it to project team members (Clark & Fujimoto, 1991). However, even though this aspect of project leadership is, we think, compelling, our understanding of exactly what vision is, what an effective product is, and the theoretical links between the two is very weak (link 5 in the model). As we discuss further in our suggestions for future research, understanding this creative task is an important research direction.

Finally, project team leaders also are small-group managers of their project teams. Surprisingly, however, there is very little research about appropriate internal *management skill* for project leaders beyond studies of matrix communication and leadership (Joyce, 1986; Katz & Allen, 1985).

Perhaps, simply, the general research on leadership of small groups applies here.

Senior Management

Although the team and project leader are critical in the product-development process, senior management is important as well. Consistent with studies in the rational stream, senior management support is critical to successful product-development processes (e.g., Cooper & Kleinschmidt, 1987; Gupta & Wilemon, 1990; Rothwell, 1972; Zirger & Maidique, 1990). By support we mean the provision of resources to the project team, including both financial and political resources. The underlying reasoning is that this support is essential for obtaining the resources necessary to attract team members to the project, to gain project approval to go ahead, and to provide the funding necessary to foster the development effort. Thus, as shown in Figure 1, senior management support is essential for fast and productive product development. This link (6 in the model) is well supported in the literature (e.g., Cooper & Kleinschmidt, 1987; Gupta & Wilemon, 1990; Katz & Allen, 1985; Zirger & Maidique, 1990).

Second, as described by Imai and colleagues (1985) in the problem-solving perspective, the ability of senior management to provide what they term *subtle control* also is important to both superior process performance and effective products. Much like the vision of project leaders, subtle control involves having the vision necessary to develop and communicate a distinctive, coherent product concept. As we described previously, senior management and project leaders often work together to develop such a product concept. At the same time, subtle control also involves delegation by senior management to project teams such that they have enough autonomy to be motivated and creative. We argue that such creativity and motivation are likely to yield a better development process. However, as in the case of project leader vision, the subtle control and product effectiveness concepts and their theoretical links are blurred and lack rigorous empirical examination (link 7 in the model). We will discuss this lack of clarity in our suggestions for future research.

Suppliers and Customers

The final key players in the model are suppliers and customers. Previous research has associated a faster development process with early (Gupta & Wilemon, 1990) and extensive (Clark & Fujimoto, 1991; Imai et al., 1985) supplier involvement. As explained in the problem-solving stream, extensive supplier involvement in product design can cut the complexity of the design project, which in turn creates a faster and more productive product-development process. Such involvement also can alert the project team to potential downstream problems early on, at a point when they are easier and faster to fix. Customer involvement also

has been shown to improve the effectiveness of the product concept in the rational plan stream (e.g., Cooper & Kleinschmidt, 1987; Zirger & Maidique, 1990). However, it is not clear exactly how or when suppliers and customers are appropriately involved in the development process, and the evidence is not unanimous (e.g., Eisenhardt & Tabrizi, In press). Thus, even though the participation of these outside constituents is probably important, the empirical literature is imprecise (links 8 and 9 in the model). Again, we address this in our discussion of future research.

Financial Success

The previous discussion linked the key players in product development to process performance and product effectiveness. The final portion of the model combines these two factors with characteristics of the market to predict the financial performance of the product.

The underlying rationale for the link (10 in the model) between *process performance* and *financial success* of the product is twofold. A productive process means lower costs and thus, lower prices, which, in turn, should lead to greater product success. Second, a faster process creates strategic flexibility and less time to product launch, both of which may lead to financially successful products. The second predictor of the financial success of the product is *product effectiveness* (link 11 in the model). As shown in the rational plan literature (e.g., Cooper & Kleinschmidt, 1987; Zirger & Maidique, 1990), product characteristics such as low-cost and unique benefits and fit-with-firm competencies create financially successful products. Presumably, such products are more attractive to consumers.

Finally, consistent with research in the rational stream (Cooper & Kleinschmidt, 1987; Zirger & Maidique, 1990), the third link (12 in the model) ties a *munificent market* to financial success. Specifically, we define a munificent market as one that is large and growing and has low competition. The reasoning is that such markets offer the possibility of large sales and, in the case of growing markets, competitive instability that may favor new products.

Overall, the argument is that a strong product-development process, an attractive product, and a munificent market should lead to a financially successful product. However, although these links have some substantiation in the rational plan literature and seem plausible, they have received little rigorous testing and rely on limited theoretical logic. As we will discuss, this portion of the model presents another excellent opportunity for future research.

AGENDA FOR FUTURE RESEARCH

As noted in the previous section, many of the concepts and theoretical links presented in the model in Figure 1 have been well studied. However,

some concepts are less sharply defined, and some theoretical links are not well tested. These shortcomings present research opportunities.

One research opportunity is to examine the primary links of the model—that is, the links among process performance, effective product, market factors, and financial performance. As was noted, these links have been primarily empirically examined in the rational plan research stream. However, because the methodology in this research stream so often involves subjective, retrospective responses by single informants and bivariate analysis, the validity of these links is tenuous. Thus, a test of these fundamental theoretical links would be useful. A related research opportunity is determining the relative importance of these factors. For example, although Cooper and Kleinschmidt (1987, 1993) found that the market was not as relevant as other variables in predicting product success, it would be useful to examine the robustness of this claim.

Another related opportunity is to examine whether process performance, product effectiveness, and munificent markets are actually independent variables. For example, market factors may moderate the relationship of process performance and product effectiveness to financial success.² It may well be that process performance and product effectiveness are important predictors of financial success only in poor markets, whereas most products will be successful in munificent markets. This reasoning reemphasizes the need to garner a better understanding of the relative importance that these factors have in driving financial performance.

A second area of research is the organization of work. As was noted, two models have emerged to describe alternative organizations of work. One is the fairly well-studied model that includes extensive planning and overlapped development stages (e.g., Hayes et al., 1988; Iansiti, 1993) that was developed in the context of complex products in mature markets. A more recent model, related to improvisational thinking, emphasizes experiential product development such as frequent iterations, testing, and milestones (Eisenhardt & Tabrizi, In press), yet this second model has received only limited empirical examination. Indeed, other research suggests that our understanding is incomplete. For example, Tyre and Hauptman (1992) argued that the degree of system-level change is another contingency factor in the organization of work. In addition, a provocative study by Benghozi (1990) of a massive, long-term innovation project in the French telecommunication industry sketches a third model. For huge and lengthy projects, Benghozi (1990) suggested that *innovation routines*, which include dynamic planning, monitoring, and scheduling projects over time as the environment changes, are needed. Overall, the point is that exploring contingent models for the organization of work is an important path for future research.

² We thank an anonymous AMR reviewer for this insightful suggestion.

Third, our understanding of how senior managers affect development is incomplete. They are consistently found to be important contributors to project success (e.g., Clark & Fujimoto, 1991; Cooper & Kleinschmidt, 1987; Zirger & Maidique, 1990). However, the management-related concepts in Figure 1 such as vision, subtle control, and even support are vague. There is also little understanding of the links between product effectiveness and the creative processes by which senior managers and others match firm competencies with market needs to create an effective product concept. This process has been virtually unexplored. In addition, previous research (and thus our model) is vague regarding how the responsibilities of senior management are distinct from the responsibilities of project leaders. For example, should senior managers or project leaders be responsible for ensuring that products are synergistic with the core competencies of the firm (Leonard-Barton, 1992)? Most important, the model echoes the product-development literature in conceptualizing only two levels of management: a project leader and senior management, yet in reality, frequently there are several levels of management with presumably different responsibilities. How do these levels interact? How do these members of different levels of management affect technology strategies and the management of multiple product-development projects for which they are responsible? Thus, the concepts surrounding senior management and its link to product effectiveness offer prime opportunities for future research.

CONCLUSION

We began this paper by noting that product development is the nexus of competition for many firms as well as the central organizational process for adaptation and renewal. Simply put, product development is critical to the viability of firms and an important core competence, yet it is challenging to understand the findings of the related empirical research because this literature is so fragmented and varied.

The article has three conclusions. One is that the product-development literature can be organized into three streams of research: product development as rational plan, communication web, and disciplined problem solving. We have highlighted these three streams of research as well as their key findings, strengths, and weaknesses. Second, we conclude that these streams can be synthesized into a model of factors affecting product-development success. Given the complementary nature of past research, we were able to craft an integrated conceptual perspective that combines many of the empirical findings. Third, we conclude that there are research implications for the future based on the mixture of support for various findings in the model. We developed a brief outline of potential research paths based on constructs and theoretical links that are fuzzy or less explored in our model and the literature as a whole. Overall, this article attempts to contribute an understanding of past literature, a model of current thinking, and a vision for future research.

We end by looping back to the wider innovation literature. As we noted at the outset, there are two broad areas of inquiry (e.g., Adler, 1989) that complement one another. The economics-oriented branch offers an understanding of innovation across industries and the evolution of technologies that provides a useful context for thinking about product development. However, even in more organizational-level work in this branch (e.g., Nelson & Winter, 1982), the actual process of product development is still largely a "black box." At best, this work simply describes the evolution of idiosyncratic innovation routines within organizations (Nelson & Winter, 1982). More often, there are no organizational effects at all. Complementary to this branch of innovation research, the product-development literature opens up that black box by providing depth and rich understanding of how actual products are developed within firms, a critical core capability for many firms. This research indicates the organizational structures, roles, and processes that are related to enhanced product development. Although much remains to be explored, the product-development branch remains essential for a complete picture of innovation.

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