



Integrating R&D and Marketing: A Review and Analysis of the Literature

Abbie Griffin and John R. Hauser

During the past 20 years, numerous studies have explored the R&D–marketing interface and its role in the new product development (NPD) process. Academics and practitioners (including a PDMA task force) have examined commonly used measures of success, the underlying reasons for the success or failure of NPD projects, and the effects of R&D–marketing integration on both project- and company-level success. Does this mean we have all the answers when it comes to ensuring the necessary level of cooperation and interaction between R&D and marketing? Of course not.

Abbie Griffin and John R. Hauser note that prior research on R&D–marketing integration is being reassessed in light of the movement toward flatter organizational structures and cross-functional teams. To facilitate that reassessment, and to help guide future research in this area, they review recent research on the methods employed for integrating R&D and marketing, and they propose several hypotheses regarding those methods. They present their review and hypotheses within the framework of a causal map they have developed for studying functional integration.

The causal map links cooperation to NPD success along situational dimensions, structural and process dimensions, and outcome dimensions. The desired outcome in any NPD effort is the timely commercialization of a profitable product. The situational dimensions address the amount and types of integration needed in a project, which depend on such factors as the project phase and the level of project uncertainty. The structural and process dimensions focus on the actions taken to achieve functional integration. These include relocation and physical facilities design, personnel movement, informal social systems, organizational structures, incentives and rewards, and formal integrative management processes.

The proposed hypotheses focus on the methods for achieving functional integration—that is, the structural and process dimensions of the causal map. At first glance, these hypotheses seem to state the obvious. For example, few would challenge the notion that quality function deployment eliminates barriers to functional integration and improves information sharing between functions. However, achieving those benefits requires the presence of other factors such as senior management involvement. Rather than examine these hypotheses separately, researchers should explore the relative merits of the methods for achieving functional integration. In other words, future research must consider both the situational and the structural and process dimensions of this framework.

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Introduction

To succeed in today's marketplace, most corporations must engender cooperation between the marketing and R&D functions. It was not always so. In earlier eras, expertise could be centralized in a single person who knew (or developed) the product technology, production process, and means to market goods to others. For example, a blacksmith knew where to get raw materials, how to maintain the forge fire, and how to shape metal. Customers sought out the blacksmith and explained their needs. He asked the questions required to understand their needs and made the product, developing new features and production techniques to meet any special conditions as he went along. If he did these tasks well, he lived well. If he failed at any of these tasks, he starved. The marketing and R&D functions were integrated in the activities of the blacksmith. Market feedback was quick, obvious, and persuasive.

Even today in entrepreneurial firms, the producer-inventor frequently combines the knowledge of what is needed with how to develop it. But as the firm grows, the marketing and R&D functions become specialized. Scientists are hired to maintain and develop technology; marketing specialists are hired to sell the product, talk to customers, and communicate product

benefits. Over time these groups grow apart, each expert at their own function, but less aware of the other's contribution. As integration and communication between these critical functions decreases, their ability to combine skills to develop and produce successful products decreases. The firm suffers.

Marketing and R&D both provide input to many tasks. Some are core tasks upon which the success of the enterprise rests. For example, marketing and R&D share responsibilities for setting new product goals, identifying opportunities for the next generation of product improvement, resolving engineering design and customer-need tradeoffs, and understanding customer needs. These responsibilities require cooperation throughout the entire task and the combined expertise of both functional groups. Other tasks are dominated by one or the other group. For example, marketing often has dominant responsibility for finding and assessing new applications for products and technologies, trouble-shooting customer problems, producing accurate product literature, and selecting advertising claims, whereas R&D may have dominant responsibility for establishing long-term research directions, keeping abreast of competitive technology, and identifying and fixing design flaws for future product releases. Most of the expertise to complete these tasks resides within one group; the other functional group is called upon for consultation, usually in a discontinuous manner during critical periods.

Marketing and R&D responsibilities in new product development are neither independent nor static; they cannot be analyzed separately. Responsibilities evolve as new technological solutions become available, as customer needs change, as competitors offer new products, and as governmental and environmental constraints shift. Long-term profitability requires repeated product (or service) renewal. Money, materials, information, and technical expertise flow across the boundaries between the functional areas to continue developing products [92,93].

The need for managing flows across marketing and R&D boundaries was recognized as important in the 1970s, and research in the area was initiated [92,101,105]. Managing the interface became critical in the 1980s and has continued to be important to firm success since then [109]. Firms started feeling intense competitive pressures to reduce new product development cycle times and manufacturing lead times. Leaner management sought a greater success rate for new product introductions with less wasted expense. Many firms are experimenting with flatter manage-

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ment structures, cross-functional teams, and cross-discipline management processes. Innovations in the way corporations manage the marketing and R&D functional groups has led to new perspectives in the academic literature. Research prior to this period, which assumes hierarchical corporate structures with separate (and sometimes isolated) functional groups, is now being reassessed in light of interfunctional innovations.

This article examines the impact on new product development of communication, cooperation, and integration of the marketing and R&D functions. We review recent academic research and practice in marketing and product development. Our goals are to explore the interfunctional perspective, highlight recent trends, propose a causal map for studying integration, and suggest researchable propositions that link mechanisms to outcomes. Some aspects of the interface are well understood, whereas others are in flux. The latter present the greatest challenges.

Cooperation, When It Occurs, Often Leads to Success

What Is Success?

To assess the effect of cooperation on success, we must first define success. Firms develop new products to earn long-term profits. However, it is often difficult to link aggregate profit measures to individual product-development projects or even programs. As a result, a wide variety of success measures has been reported (for reviews, see [11, 16, 18, 49]). Most recently, a Product Development and Management Association (PDMA) Task Force [41] reviewed the most common measures currently used by surveying 77 published articles and 50 best-practice firms. The measures grouped into five categories: customer measures (e.g., market share, customer satisfaction), financial measures (e.g., profit goals, margins), process measures (e.g., technical performance, on-time delivery), firm-level measures (e.g., success/failure rate, % of sales in new products), and program measures (e.g., new-product program achieved its objectives). On average, success was judged by three to four specific measures across two to three categories.

Both academics and firms focus on revenue goals, profit goals, and time-to-market success measures. Many academic researchers employ firm-level mea-

ures (% of sales from new products, success/failure rate) and process measures (technical success, subjective success, completion within budget) as additional measures of success, whereas firms prefer to use customer measures (market share, volume, customer satisfaction) and financial measures (margins). In part, these differences arise because academics are exploring the root causes of success—they have a greater need to link cause to outcome and seek measures that allow them to compare across firms. Firms are more interested in evaluating people and projects (and face profit pressures), thus they focus on measures that allow them to manage specific people and projects.

These varying definitions are important to keep in mind as we review the impact of cooperation. Firms believe cooperation is important and, especially in the past 5 years, have taken steps to improve cooperation. The academic literature provides evidence that cooperation leads to success. However, all conclusions are relative to the measures of success that are used.

Evidence That Cooperation Increases Development Success

Table 1 summarizes some of the scientific evidence that relates to cooperation between marketing and R&D. In each case the research either supports or is consistent with the hypothesis that cooperation enhances success. The evidence is strong, consistent, common across a variety of methodologies, and seemingly applicable in both services and products and in both consumer and industrial markets. We discuss three examples to illustrate some of this research.

For example, a 10-year study of 289 projects provides evidence that interfunctional harmony (communication *and* cooperation, not just communication) strongly correlates with project success [106]. It was also found that friendship differs from cooperation—too much socializing at the expense of professional interaction was harmful because it prevented much needed objective criticism.

At a more detailed level, retrospective interviewing and project paper-trail analysis have been combined to study nine pairs of successful and unsuccessful new product projects at industrial, consumer, and service firms [28]. Using a 3-point scale, communication on nine topics related to the user, marketing strategy, and the physical product was measured. The data suggest that there is sporadic communication

Table 1. Examples of the Scientific Evidence Suggesting that Communication among Marketing and R&D Enhances New Product Success

Researcher(s)	Sample	Type of Firm	Evidence (Partial List)
Cooper [19]	58 projects	Industrial	Projects that balance marketing and R&D inputs have a higher rate of success.
Cooper [20]	122 firms	Electronic, heavy equipment, chemicals, materials	Management strategies that balance marketing and R&D have a greater percentage of new product successes and greater percentage of their sales coming from new products.
Cooper and de Brentani [23]	106 projects	Financial services	Synergy (e.g., fit with the firm's expertise, management skills, and market research resources) was the number one correlate of success. (Correlation = 0.45.)
Cooper and Kleinschmidt [24]	125 firms 203 projects	Manufacturing	Market synergy and technological synergy are both significantly related to success.
de Brentani [26]	115 firms 276 projects	Financial and mgmt services, transportation, communication	Sales, communication between functions. (Correlation with sales and market share = 0.38, correlation with reduced cost = 0.29.)
Dougherty [28]	5 firms 18 projects	Industrial, consumer, and services	More communication and communication on <i>all</i> relevant topics separated successful projects from unsuccessful projects.
Gupta, Raj, and Wilemon [46]	167 firms 107 R&D managers 109 marketing managers	High-technology	Lack of communication was listed as the number one barrier to achieving integration among marketing and R&D.
Hise, O'Neal, Parasuraman, and McNeal [57]	252 Marketing Vice Presidents	Large manufacturing firms	High level of joint effort in new product design is a significant factor in determining success. This is true for both industrial and consumer good companies.
Moenaert and Souder [73]	Literature review	Products and services	Function integration positively relates to innovation success.
Moenaert, Souder, DeMeyer, and Deschoolmeester [74]	40 Belgian firms	Technology innovative firms	Significant correlation between commercial success and (1) interfunctional climate, (2) information received by R&D.
Pelz and Andrews [85]	1311 scientists and engineers	Scientists and engineers	Positive relationships between the amount of interaction and performance.
Pinto and Pinto [86]	72 hospital teams 262 team members	Health services	Strong relationship between cross-functional cooperation and the success (perceived task outcomes and psychosocial outcomes) of the project. (Correlation = 0.71.)
Souder [106]	56 firms 289 projects	Consumer and industrial	The greater the harmony between marketing and R&D, the greater the likelihood of success.

Table 1. Continued

Researcher(s)	Sample	Type of Firm	Evidence (Partial List)
Souder and Chakrabarti [108]	18 firms 117 projects	Consumer and industrial	Interaction, integration, and information exchange significantly differentiate between technical and commercial success and failure.
Takeuchi and Nonaka [111]	6 projects U.S. and Japan	Consumer and industrial	Cross-fertilization and self-organizing teams led to success.

among team members associated with failed products and uniformly high communication across many topics among team members involved in the successful products. Although this analysis is based on a small sample of qualitative judgments, it suggests that communication enhances success.

Other studies investigate success at the firm level, looking for strategies that lead to improved corporate performance. Cooper surveyed 122 organizations on 66 strategic variables [20,21]. He factor-analyzed the 66 variables to obtain 19 strategic dimensions across which he then cluster analyzed the organizations to obtain five basic developmental strategies. The one group of firms with consistent success, in terms of both the percent of new products successful in the marketplace and sales generated by those new products, were those that balanced marketing and technology function inputs through better communication and cooperation. Cooper contrasted this success with technology-driven firms, which had an above average percent of sales from new products, but at the expense of a very low success rate, and low-budget, conservative firms, which had a high success rate, but a low percentage of sales from new products. Other firms did poorly on both measures.

Although the research investigating the relationship between R&D and marketing suggests that cooperation and communication are correlated with product-development success, many other researchers have found and investigated numerous barriers to communication and cooperation.

Barriers to Communication and Cooperation

There are many barriers to achieving cooperation and communication between marketing and R&D [11, 108]. As a result "Empirical research indicates that disharmony between marketing and R&D is the rule, rather than the exception" [73, p. 96]. From a survey of 274 R&D and 264 marketing managers, Song

[98] found the correlation between the stated ideal level and the achieved level of integration to be 0.55; achieved integration was only about half of the desired state.

Much research has explored barriers to cooperation. In this section we review that research, starting with barriers arising from the people themselves and moving into different firm-related barriers. In later sections, we review (1) the causal structures that are being used to understand the interrelationship between the barriers and (2) methods to overcome these barriers.

Personality

Inherent personality differences have been found between marketing and R&D personnel in American corporations (Table 2) [94]. Some differences are stereotypes, many may have changed since 1968, and many may be unique to America's culture, but these differences do caution that there may be some natural interpersonal distance between marketing and R&D [13,66]. Interestingly, recent research has shed new light on these findings. Marketing and R&D managers at 167 high-technology firms were similar on many traits—differences existed mainly in time orientation [44]. Furthermore, this difference was observed whether or not marketing and R&D were well integrated in the firm. However, cultural barriers were two of the four most frequently cited barriers to cooperation. This suggests that the true barrier may be a perceptual barrier of stereotypes rather than of actual personality differences. When they exist, these stereotypes can form formidable barriers between the groups. Even if the stereotypes are not based in fact, if one or the other group believes in them, this belief alone can become a barrier to mutual understanding.

Because personality or stereotype barriers may be the most difficult of all communication barriers to reduce or eliminate [10], the existence of these barriers suggests researchers seek mechanisms to enhance understanding and to build trust between functions.

Table 2. R&D and Marketing Stereotypes (Saxberg and Slocum [94])

R&D Traits		Marketing Traits
	Goals and aspirations:	
<ul style="list-style-type: none"> ● Knowledge as a source of value to mankind ● Research for research's sake ● Peer evaluation and recognition 		<ul style="list-style-type: none"> ● Organizational survival and growth ● All activities relevant to firm's objectives ● Organizational recognition
	Needs:	
<ul style="list-style-type: none"> ● Autonomy ● Peer recognition, creative environment ● Continuing education and development ● Support for advancing knowledge in society 		<ul style="list-style-type: none"> ● Plans, procedures, policies, rules ● Organizational recognition ● Team work ● Increased organizational status
	Motivation:	
<ul style="list-style-type: none"> ● Service to mankind ● Publications ● Professional recognition ● Patents with name attached ● Freedom to solve problems, and advance knowledge 		<ul style="list-style-type: none"> ● Rewards and sanction system with pay and advancement through organization

Cultural Thought Worlds

Marketing and R&D personnel often differ in training and background. Marketing professionals are drawn primarily from business schools, often with a prior liberal arts background. R&D professionals are hired primarily from engineering and science schools. Business school training focuses on general problem solving, combining data and intuition to make decisions that lead to profitable corporate performance. Science and engineering school training focuses on the scientific method of hypothesis generation and testing and solving technical problems. These world views and organizational routines are reinforced in the cultures of the firm's functional departments [28,29,31].

First publicized in 1967 [64], the cultural differences between marketing and R&D (Table 3) have been well documented [44,94,105]. Marketing thought worlds prefer the short time horizon of incremental

Table 3. Marketing and R&D Differences (adapted from Lorsch and Lawrence [65], Gupta et al. [44], and Dougherty [29])

Dimension	Functional Position	
	Marketing	R&D
Time orientation	Short	Long
Projects preferred	Incremental	Advanced
Ambiguity tolerance	High	Low
Departmental structure	Medium	Low
Bureaucratic orientation	More	Less
Orientation to others	Permissive	Permissive
Professional orientation	Market	Science
Professional orientation	Less	More

projects. They focus on the market, accept a high degree of ambiguity and bureaucracy, and feel loyalty to the firm. By contrast, R&D thought worlds prefer the long time horizon of advanced projects. They focus on scientific development with a loyalty to their scientific profession and have low tolerances for ambiguity and bureaucracy. Naturally, these generalities do not apply to every marketing or R&D department, but rather indicate identifiable trends.

These differences in thought worlds suggest that marketing and R&D run the danger of developing self-contained societies in which they reside. Even though both functions work for the same corporation with the same overall corporate goals, the lens through which each function interprets those goals differs [100]. More importantly, separate thought worlds mean that marketing and R&D may have difficulty understanding one another's goals, solutions, and tradeoffs. To work together they must understand and appreciate the other's thought world.

Language

As separate thought worlds develop, language barriers also arise. Marketing has and uses its own set of technical terms, and R&D uses different technical terms. Marketing professionals speak in terms of product benefits and perceptual positions. R&D professionals speak the quantitative language of specifications and performance. When miscomprehension occurs, customer needs and engineering solutions disconnect even though each group thinks they are talking about exactly the same thing. Subtle differences in language

often imply vastly different solutions and can make the difference between a successful and an unsuccessful project [39].

Even the level of detail used by each group varies. For example, marketing may find that consumers want a liquid dishwashing detergent to "clean my dishes better." This statement may be adequate for devising advertising strategy, but to design the "best" solution, R&D needs to know what kind of dishes, what dirt has to be removed, and in what type of water. Different solutions can be developed if the consumer judges "clean" by spots on the glasses, a shine on the dishes, the amount of bubbles during the washing process, or, as was the case in one application we observed, by the size and shape of the bubbles. If each group does not understand customer needs at the level of detail that they need to do their job, they become frustrated with the communication process [38].

Organizational Responsibilities

Organizational barriers arise due to different task priorities and responsibilities [29,99,109], functional success measures unsupportive of integration (market share vs number of patents) [109], lack of top management support rewarding integration [53], and the perceived illegitimacy of product development [30]. Whereas top management clearly controls these factors, organizational change to eliminate these differences can create barriers in and of itself. Middle managers who have risen to where they are under the previous criteria now must learn to play by different rules to continue to rise in the organization. Because they have become proficient and successful under the old system, many are reluctant to change to new operating rules or philosophies. The confusion and angst can cause resistance to any "outsiders" and thus reduce cooperation among marketing and R&D.

Physical Barriers

Physical barriers frequently isolate marketing from R&D in U.S. firms. It is not uncommon for R&D facilities to be located on "campuses" in cities distant from the marketing offices. At a major computer company, the marketing offices are located in a northern state, whereas the R&D effort is headquartered in a southern state. The probability that two people communicate at least once per week drops off rapidly with the physical distance between their offices, with the

probability of communication less than 10% at office separations of 10 meters [4]. When marketing and R&D are in separate cities, there is much less interpersonal activity even with new communications technology.

Separation decreases chance meetings, serendipitous information transfer or problem clarification in the halls or around the coffee machine. Long distances between groups make face-to-face communication inconvenient, leading to decision-making delays. Physically isolating groups exacerbates other communication barriers. Isolation solidifies separate thought worlds, encourages short-cut, jargon-filled language development, and heightens perceptions of personality differences [3].

Conclusions about Barriers to Cooperation

The general outcome of personality, cultural, language, organizational, and physical barriers between marketing and R&D means that communication and cooperation are difficult to achieve in many U.S. firms. Such misunderstanding can lead to strong "not invented here" attitudes, where each function supports the data and work generated only from within their own group.

Combining the evidence of these barriers with the scientific evidence that communication between marketing and R&D is one key success factor in developing new products and generating sales, we hypothesize that such barriers must be either eliminated or circumvented if the firm is to be profitable in the long-term. We also recognize that the need for integration is at least somewhat situational [13]. For example, corporations invest in some research to maintain a core expertise, say in stepping motors or in polymers. Such efforts require less communication between functions than efforts to turn those technologies into products that fulfill customer needs. Not all companies in all operating environments, or even all projects within a particular company, need to achieve equal levels of cooperation for successful development. The next section reviews research and models that examine integration, situation-specific phenomena, and successful development.

Proposed Factors Mediating the Need for Cooperation

Two groups of researchers have developed conceptual models delineating marketing and R&D interactions

for product development. They, and others, have begun testing the validity of their models. Both models propose specific situations that affect how marketing/R&D integration impacts the success of the development effort. The conclusions of this research support the contention that the amount of integration between marketing and R&D required depends on the environment within which product development occurs [13].

Gupta, Raj, and Wilemon [43] pose a model (Figure 1) and 13 propositions which posit that the degree of integration for which the firm should strive depends on the organization's innovation strategy [72] and the perceived environmental uncertainty within which the firm operates. Their unit of analysis is the business unit or the firm. Higher environmental uncertainty and strategies targeting leading-edge (riskier) technology or product positions lead to an increased need for R&D/marketing integration. The evidence with respect to this model has been mixed. Parry and Song [82,84] have tested the constructs of Gupta et al.'s model by surveying Japanese high-technology firms, generally finding support for the hypotheses. They found that Japanese managers in firms emphasizing opening up new markets and new product areas ("prospector" firms [72]) perceive a higher need for integrating marketing and R&D than do firms which pursue more cautious innovation routes (analyzers). In turn, analyzer firms see more need for integration be-

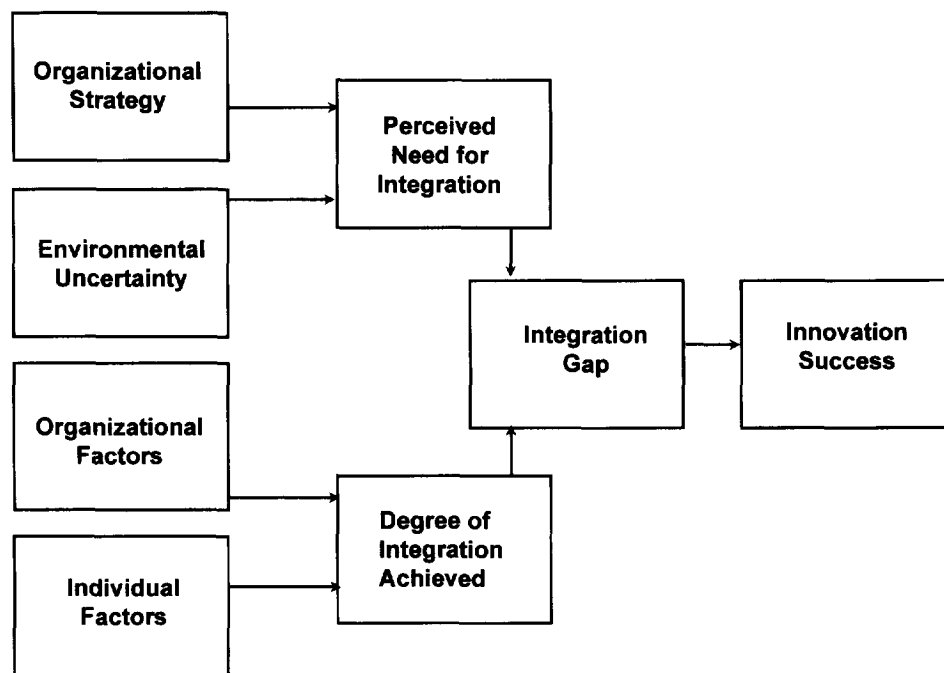
tween marketing and R&D than firms who place little emphasis on innovation (defenders). The success of those studies suggests further research to determine the underlying economic forces that cause some firms (or groups within firms) to be prospectors, whereas others are analyzers, defenders, or reactors. For example, Parry and Song found that high consumer-demand uncertainty and high rates of technological change drive managers to believe that they need better marketing/R&D integration.

Another analysis of these Japanese survey results concluded that higher self-stated integration levels for five product-development tasks (of 19 total) correlated with higher self-rated product-development program success according to both R&D and marketing managers [83]. More-integrated tasks which both groups indicate lead to higher success include:

- establishing development goals and priorities,
- analyzing customer needs,
- designing user and service manuals,
- designing communication strategies, and
- information sharing about competitor strategies and reactions.

R&D managers also associate higher perceived levels of integration in determining customer requirements,

Figure 1. Model of the marketing/R&D interface (Gupta, Raj, and Wilemon [43]).



analyzing test market results, and gaining customer feedback on performance with higher program success. These tasks are spread throughout product development. The survey and analysis has been replicated for U.S. chemical firms [78]. This research team also plans to repeat the survey for German chemical firms and compare the results to those obtained for U.S. and Japanese firms.

Other research consistent with the model reports that U.S. firms with more successful product-development programs have more integration between marketing and R&D than firms with less successful programs [46]. More successful firms achieve more integration in the following tasks:

- analyzing customer needs,
- generating and screening new ideas,
- developing new products according to the market's needs,
- analyzing customer requirements, and
- reviewing test market results.

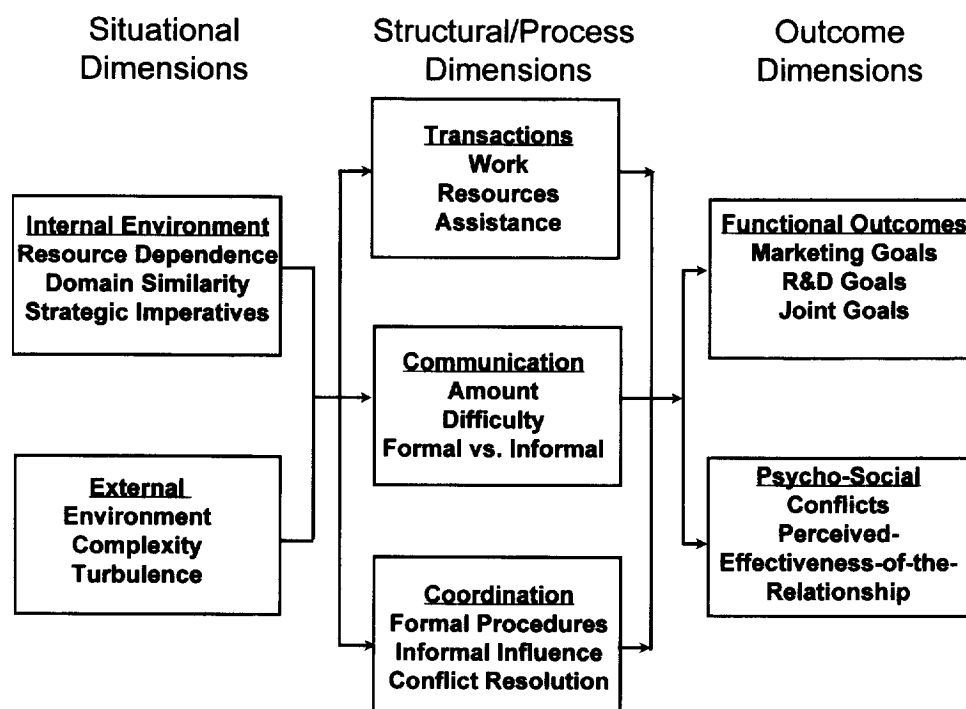
However, contrary to the expectations from their model, these results were not mediated by strategy or

uncertainty level. Some of the hypotheses were questioned further in research on U.S. high-tech firms [42] and with a pilot study of survey-generated results [45].

Ruekert and Walker [93] hypothesize a more detailed model of how the marketing/R&D interface operates. Their framework and 14 propositions examine how, how effectively, and why marketing personnel interact with personnel in other functional areas when planning, implementing, and evaluating marketing activities. The authors have transformed each proposition into testable constructs and have tested parts of the framework by using survey responses from marketing, R&D, manufacturing, and accounting personnel in three divisions of one *Fortune 500* firm.

Ruekert and Walker [93] start with the firm's organizational and working environments. However, their model contrasts with [43] because these factors feed into a delineation of the management situations and processes that govern both whether interaction and integration are achieved as well as specifically how they have been achieved (Figure 2). Ruekert and Walker predict that more interdependence, task and work similarity, formal between-group interactions, and influence between groups lead to less conflict and higher transaction flows (flows of resources, work, and assistance) and perceived effectiveness between the groups. In a small pilot study, they found support for the basic proposition that marketing and R&D in-

Figure 2. Model of the marketing/R&D interface (Ruekert and Walker [93]).



teraction results from and is influenced by perceived resource dependencies in completing tasks. The more one function believes they depend on another function, the greater the interactions and resource flows across the functional boundaries and the more influence the information-providing group has over the information-receiving group.

A model describing communications between two market channel participants nicely complements the R&D/marketing interface models. Mohr and Nevin [75] summarize the literature and posit relationships between (1) communication frequency, direction, content, and modality and (2) the structural, climatic, and power conditions for two firms cooperating in a marketing channel. Their theory suggests that these strategies and conditions impact the qualitative channel outcomes of coordination, satisfaction, and commitment which, in turn, lead to quantitative channel performance. Like the R&D/marketing interaction models, this model tries to understand how coordination and communication between two independent groups, who both have inputs into a task, affects outcomes and how the effects vary by corporate situation.

Some Implications of Previous Research

Evidence links cooperation and communication to new product success. The Gupta et al. [43] model suggests how one might analyze the desired level of marketing/R&D integration, given a firm's strategy and environment. The unit of analysis is integration at the overall divisional level. The success measures used in [45,46,81-84] are the program-level measures favored by academics, not project-level measures and analyses used more frequently by industry [41].

Ruekert and Walker's [93] model may be more appropriate for analyzing interfaces within one company or within a set of companies facing similar environments, using similar strategies. This model may help determine whether a particular technique a company employs for integrating across the two groups actually changes anything. The model can be used to diagnose which aspects of integration a company might want to improve. It does not, however, identify solutions to particular integration problems.

The Ruekert and Walker model and the channels model of Mohr and Nevin postulate better outcomes with enhanced communication. Each model highlights the domain-specific situational dimensions and recognizes the relationship between the (short-term) mea-

surable outcomes and the more qualitative (long-term) outcomes. Like the Gupta et al. model, the Mohr and Nevin model recognizes that organization structure and business environment impact the need for communication and that success is a function of both the need for communication and the amount achieved. In the next section we synthesize across the contributions of these three models to propose a broader causal map around which future research on R&D/marketing integrating mechanisms at the project level can be organized.

Causal Map for Linking Cooperation to Development Success

Today's flatter organizations suggest that more product and service development is decentralized and managed project by project. Thus, we draw upon the division- and firm-level research (Figures 1 and 2) and upon the project-level research (e.g., [73,92,99,103,105, 106,108]) to propose a causal map to focus research on integrating mechanisms at the project level. This map (see Figure 3) combines and extends the models in Figures 1 and 2 based on published research to date. We choose the structure and the language of the causal map to facilitate research on and evaluation of particular integration problems and their proposed solutions.

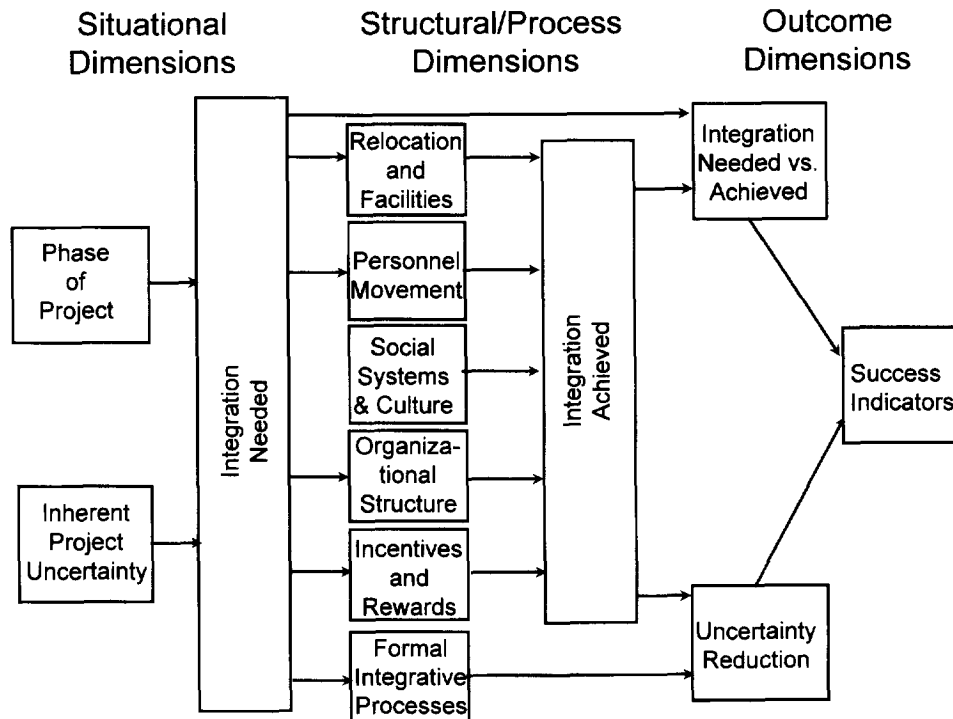
Like Ruekert and Walker, we organize and causal map in terms of situational dimensions, structural/process dimensions, and outcome dimensions. The situational dimensions recognize that since R&D projects vary, the right amount and the type of integration will vary as well. The structural/process dimensions suggest actions the firm can take to achieve integration. These actions will depend on the situation the firm faces. The outcome dimensions measure the impact of integration on both final outcomes and intermediate process outcomes.

We begin with the outcome dimensions and work backward. We caution the reader that we have chosen to draw this map in the "English-language" format. Naturally, many of these management constructs will have multiple indicators, and the indicators might be based on multiple measures. The researcher may wish to redraw this diagram in the more traditional causal model format to stress the multiple indicators of the constructs and to indicate measurement error.

Outcome Dimensions

The objective and desired outcome in new product development is to commercialize a successful and

Figure 3. Causal map for studying the project-level marketing/R&D interface (detail on the aggregate constructs is given in the text).



profitable product in a timely fashion. We label the primary outcome measure “success.” It can be operationalized by a combination of the measures reported in the PDMA Task Force study cited earlier: customer measures such as market share and customer satisfaction, financial measures such as profit goals and margins, process measures such as technical performance and time to market, firm-level measures such as success rate and percent of sales from new products, and program measures such as whether the team was satisfied with the outcomes. This last, psychosocial measure, should not be minimized. Integration requires a changed organization, and changing an organization takes time. Early in the implementation of any management program the psychosocial measures may be the only ones that are measurable, but if the psychosocial goals are attained, then this is an auspice for long-term success.

To achieve success, development uncertainties inherent to the project must be reduced and the marketing/R&D integration that is achieved must match the level of integration that is needed. The evidence we cited earlier suggests that each of these intervening outcomes is a necessary, but not sufficient, condition for project success. Clearly the project must choose a technology and develop a product (service) that fulfills customer needs profitably. To do this it must reduce

both technological and market uncertainty. However, the research cited earlier suggests that the technology must be matched to the market needs—integration was a clear criterion for success. However, too much integration may not be the answer if this integration means that team members lose their functional skills over time or if the team members focus too much on integration and lose sight of their other goals. Like [43] we postulate that success is more likely to occur when the integration that is achieved matches the integration that is needed. We also postulate that the actual integration achieved and the integration mechanisms chosen will impact both the technology and the market outcomes (shown as an arrow to “uncertainty reduction” in Figure 3).

Structural/Process Dimensions

We summarize the structural/process dimensions by “integration achieved.” Based on previous research [100,101], both [93] and [73] suggest that this construct is measured based on the information that is communicated and used, which transactions occur across boundaries (tasks completed and decisions made), and how much coordination is achieved (processes are followed and conflicts resolved).

There are six types of actions the firm can take to achieve integration. We show these as relocation and facilities, personnel movement, informal social systems, organizational structure, incentives and rewards, and formal integrative management processes. We review their details in the next section of this article. How each action affects integration and which actions are required depend upon the needs of the firm and its history. For example, in some firms and in some situations it is feasible to co-locate marketing and R&D, whereas in other firms management must provide explicit integrating tools and must attempt to change the organizational structure. Some of these actions are substitutes and some are complements—the full causal diagram would reflect these interactions for a specific situation. For now we have drawn them as independent effects.

Situational Dimensions

We summarize the situational dimensions with “integration needed.” The amount (and kind) of integration that is needed in a project depends upon specific situations such as the phase of the project [32,73] and the inherent project uncertainty [43,93].

For example, earlier product development phases (target market identification, need identification, idea generation, concept development and selection, and specification development) require the highest level of integration between marketing and R&D. Close integration between these two functions is less critical to success later in the process, although R&D may need to become closer to other functions, such as manufacturing, at that time.

Higher project uncertainties also lead to a greater need for marketing/R&D integration. This has been operationalized at the firm level as the strategic product direction emphasized by the firm [43]. However, uncertainties vary across projects, regardless of the overall strategic position of the firm. Project uncertainties can be broken into market (customers and competitors) and technological (technical and resource) aspects [73]. Each of the firm’s current products addresses a certain set of needs for a certain set of customers. Market uncertainty is lowest (certainty is highest) for a product-development project whose purpose is to solve the same set of needs for the current customers. Solving an expanded set of needs for current customers or the current set of needs for a new set of customers increases market uncertainty, and solving

a new set of needs for a new set of customers maximizes market uncertainty.

Each product or service also delivers a set of needs with a certain set of product-performance and process technologies. Technological uncertainty is lowest for a project that uses only the product-performance and process technologies already used in delivering this set of needs. Technological uncertainties are increased by incorporating technologies not used before in this product area, but which have been used for other purposes elsewhere in the corporation. Uncertainty is raised by incorporating technologies not used in this firm, but which other firms have employed. Technological uncertainty is maximized when the firm must invent completely new technologies, either product performance or process related.

For projects with lower uncertainties, for example an incremental change to a current product which does not change the target market or add new benefits, there is less need to achieve higher levels of integration to obtain success. The firm may produce a successful new product without implementing any mechanisms to increase integration. This is especially true in industries where technologies and market needs evolve slowly such as specialty chemicals. However, in most industries, technologies and market needs are evolving more rapidly. For these situations integration is critical. We now focus on the six types of actions that help the firm integrate across functions.

Methods to Achieve Functional Integration

Companies have been using six general approaches to integrate the efforts of marketing and R&D [4,74,93, 96,105,109]. The integration approaches, as ordered in Figure 3, are:

- relocation and physical facilities design,
- personnel movement,
- informal social systems,
- organizational structure,
- incentives and rewards, and
- formal integrative management processes.

This section explains the operation of various methods for integrating across the marketing and R&D interface, presents hypotheses for the mechanisms through which they affect success, and suggests some situa-

tions in which firms might want to adopt each integrating mechanism. Table 4 summarizes the mechanisms and the means by which they impact product development outcomes.

For each action we state a formal hypothesis summarizing both the research to date and the intuition of managers to whom we have spoken (see Exhibit 1 for a summary). Structured this way, most hypotheses seem obvious. However, they are not. Corporate actions may not always deliver the promised benefits, or may deliver the benefits only when certain co-factors are present, or may impose costs that are not justified by the benefits. For example, quality function deployment (QFD) did not always deliver promised short-term benefits, but often delivered long-term process benefits [38]. Co-factors, such as top management in-

volvement, were critical to implementation success. In addition, QFD worked better in projects that used QFD as a means to achieve a specific performance improvement rather than when it was used to improve things generally.

By stating our hypotheses formally, so that they are subject to refutation, we hope to encourage research to document or challenge these beliefs, to identify co-factors and actions that work best under particular circumstances and to quantify the costs as well as the benefits. Whereas we have stated our hypotheses separately for each integration method, we believe that one of the highest priority research topics is to determine the relative efficacy of the integration methods and how this relative efficacy varies by situation. We hope that Figure 3 facilitates this research process.

Table 4. Integrating Mechanisms and How They Impact Product Development Success

Integrating Mechanism	Barriers Overcome	Aspect of Integration	Uncertainty Reduced	Outcome Affected
Relocation and physical facilities	Physical separation	Information amount		Success
Personnel movement	Personality	Information utilization	Technology	Success
	Thought worlds	Complete tasks		Time
	Language	Resolve conflict		
Informal social systems	Thought worlds	Information amount	Technology	Success
	Language	Information utilization	Market	Profits
	Physical separation	Decisions made		Time
		Resolve conflict		
Organizational structures:				
Coordinating groups	Language	Decisions made		Success
	Org. responsibilities	Resolve conflict		Profits
Matrix organizations	Org. responsibilities	Information amount		Success
		Tasks complete		
		Processes followed		
Project teams	Thought worlds	Information utilization		Success
	Language	Decisions made		Time
	Org. responsibilities	Resolve conflict		
Incentive and rewards	Org. responsibilities	Task completion		Profits
		Decisions made		
		Resolve conflict		
Formal integrative management processes				
Phase Review process		Tasks complete	Technology	Success
		Follow processes	Market	Time
Stage-Gate process	Org. responsibilities	Tasks complete	Technology	Profits
		Decisions made	Market	Time
		Follow processes		
PACE	Language	Tasks complete	Technology	Success
	Org. responsibilities	Decisions made	Market	Profits
		Follow processes		Time
QFD	Thought worlds	Information amount	Market	Success
	Language	Information use		
	Org. responsibilities	Resolve conflict		

Exhibit 1. Researchable Hypotheses

Co-locating marketing and R&D increases market-place success by providing a higher level of information transfer across the interface, overcoming the barrier of physical separation.

Moving personnel across functions increases market-place success and decreases time to market by decreasing thought world, language, and physical barriers between the functions, increasing information utilization and cross-functional coordination, and decreasing technical uncertainty.

Temporary transfers are more effective in the long run because they enhance integration without eroding valuable functional skills.

Developing *informal cross-functional networks* reduces the language, thought world, and physical barriers to integration, enables more information to be communicated and utilized, increases coordination and decision-making, and decreases project uncertainties, leading to higher success on all three measures.

Coordinating groups achieve higher market success and profit levels by overcoming language and organizational responsibility barriers, allowing better decisions to be made and resolving conflicts. Their stability can reduce one dimension of uncertainty in extremely unpredictable environments.

Matrix organizations increase product-development success by reducing differences between functional responsibilities while increasing the amount of information available during a development project and enabling processes to be followed which lead to completed tasks.

Cross-functional project-development teams lead to higher marketplace success and shorter times to market by decreasing the barriers of functionally specialized thought worlds, languages, and organizational responsibilities, and providing a forum in which information is utilized better, decisions are made more effectively, and conflicts are resolved.

Performance evaluations, which recognize the interrelated rewards to marketing and R&D, based on ultimate product-development profits (or indicators thereof) decrease the inherent barriers between the functions due to differing organizational responsibilities and lead to increased profits by encouraging cross-functional decision-making and task completion and by providing incentives for resolving conflicts between the two functions.

Following a *phase-review process* increases product success and decreases development time by ensuring that necessary tasks are completed during development. This allows the reduction of project uncertainties.

Stage-Gate processes increase product success and decrease development time because they decrease integration barriers due to differing organizational responsibilities across functions. They also encourage task completion and decision-making, allowing the technical and market uncertainties of projects to be reduced.

Exhibit 1. Continued

Quality function development (QFD) reduces the marketing/R&D barriers of different thought worlds, languages, and organizational responsibilities and provides mechanisms to increase information utilization across the functions as well as resolving conflict between them. The processes used to build the HOQ lead to reduced market uncertainties. These improvements may lead to increased market success, but the results are more likely to be felt over the longer term rather than in QFD's first application at a firm.

Relocation and Physical Facilities

Because communication drops off rapidly with distance, one solution is to relocate people to reduce the distance between marketing and R&D. Some firms, such as Chrysler [67], have changed their physical facilities and co-located cross-functional development groups to promote the level of communication by reducing the physical separation barrier. This provides the opportunity for, but does not by itself generate, coordination or communication.

Experimenting with different layouts has determined that communication does increase with team co-location and increases more when the group works in nonterritorial spaces. Informal meeting places, with accessible black or white boards and free coffee, located at strategic points throughout buildings enhance informal (and productive or utilized) communication [4]. Corning's Decker Engineering building in Corning, NY, and Steelcase's Headquarters building in Grand Rapids, MI, have been designed around these architectural axioms for enhancing communication.

A different study has found that co-locating cross-functional product-development teams correlates with increased marketplace success [37]. This empirical evidence substantiates an earlier qualitative finding of [28]. This evidence supports:

Co-locating marketing and R&D increases market-place success by providing a higher level of information transfer across the interface, overcoming the barrier of physical separation.

However, co-location is only a partial solution to integrating marketing and R&D [4]. Providing communication opportunities through physical proximity must be complemented by providing groups with techniques that foster cross-functional relationships and encourage open-door policies [105]. It is these rela-

tionships that help break down the barriers of information.

Personnel Movement

Human movement between functional groups is one technique to improve flows across functional boundaries [5,13,87,91]. In many New Zealand firms, people rotate freely between R&D and marketing functions, frequently blurring the distinctions between the two groups and overcoming resistance to where a solution to a problem is developed [107]. People moving from one function to another bring with them contextual information that is important to understanding why decisions are made. This is particularly important when there is no formal documentation of the progress of a project. Personnel movement may decrease the technical uncertainty of a project when they bring with them answers to previously unsolved technical problems. They also bring with them a knowledge of the other group's jargon, contacts, and friendship-based links. These links reduce the barriers erected by differences in cultural thought worlds and languages across the groups, improve the probability of both information utilization and cross-functional coordination, and decrease the uncertainties associated with the project. These arguments suggest:

Moving personnel across functions increases marketplace success and decreases time to market by decreasing thought world, language, and physical barriers between the functions, increasing information utilization and cross-functional coordination, and decreasing technical uncertainty.

As a product moves toward commercialization, transferring personnel downstream with the project moves experience and know-how into the receiving function. This reduces the perception that the downstream function is "stuck" with any post-transfer problems. Similarly, upstream transfers enable the upstream group to anticipate downstream problems. It creates the impression that the downstream group has project inputs and thus creates ownership.

However, transferring personnel between closely related technical disciplines or between engineering and manufacturing is far easier than shifting personnel between marketing and R&D. As indicated earlier, the skills, knowledge, language, and culture required by each function creates barriers that are difficult to overcome. There are some solutions. At times companies

find and hire those rare individuals with dual skill sets or companies induce some of their personnel to obtain training in both areas. The creation of "Management of Technology" programs at several leading universities is a sign that such training is occurring [109]. Some companies view managers with dual skill sets as an important output of a well-managed R&D group [118]. Other companies use part-time transfers: a marketing professional goes to an R&D group as an advisor or an R&D professional spends time in the marketing function. Such transfers should be temporary to ensure that technical skills are not eroded. The transfers are a valuable means to share perspectives without asking a professional to do a job for which he or she has not been trained [109]. We postulate that not all personnel movements are equal. Specifically:

Temporary transfers are more effective in the long run because they enhance integration without eroding valuable functional skills.

Informal Social Systems and Culture

Several researchers [33, p. 50; 76, p. 12; 116, p. 410] suggest that informal contact often substitutes for formal new product processes. Many engineers and marketers claim that formal processes are not the primary means by which product development decisions are influenced in firms [85,116]. Whereas cultural differences between marketing and R&D raise cooperative barriers, informal social networks encourage open communication and provide contact both across the functions within the team as well as outside a development team to ancillary functions. Informal contacts may have the requisite expertise to solve a particular problem or may identify who has the expertise. On the other hand, without the right reward system, informal loyalties can lead one group to satisfy its internal customer at the expense of firm profits [53]. In either case, because they work outside the formal bounds of the organization and its routines, developing informal social systems can be very powerful [29]. We postulate:

Developing *informal cross-functional* networks reduces the language, thought world, and physical barriers to integration, enables more information to be communicated and utilized, increases coordination and decision-making, and decreases project uncertainties, leading to higher success on all three measures.

In addition to encouraging an informal social system, management can establish a culture that nurtures

integrated innovation. Such a culture has a high tolerance for calculated risks, is open to communication, shares rewards, and is decentralized [105,109]. Further, top management should support proactively the culture and encourage role revision through a mutual understanding of responsibilities and capabilities [105]. Management can also manage conflict by assuring involvement and creating subordinate goals [105]. See [109] for a review of such organizational design solutions to marketing/R&D integration.

Occasionally, group culture change sometimes requires a catastrophic crisis that demands change for survival [95]. Although it is nearly impossible to force such networks to develop, managers often provide opportunities through cross-functional picnics, athletic leagues and tournaments, and other recreational activities. Retreats serve the dual purpose of problem-solving and generating social networks; they sometimes justify their cost in terms of person-days diverted from projects.

Organizational Structure

A study of 80 technology-intensive companies found that each of the six organizational characteristics of Table 5 correlate highly with credibility and cooperation between marketing and R&D [47]. An effective organizational structure should incorporate these characteristics if it is to succeed at fostering cooperation between these two functions.

Table 5. Organizational Characteristics that Enhance Cooperation (Gupta and Wilemon [47])

Characteristic	Explanation
1. Harmonious operations	Discuss important issues, resolve conflicts early, work together
2. Formalization	Clear performance standards, clear responsibilities, well-defined guidelines
3. Decentralization	Issues resolved quickly by "local" knowledge
4. Innovativeness	Supports new ideas, tolerates failure, is responsive to change
5. Value cooperation	Provides opportunities to exchange views and perspectives
6. Joint reward system	Both marketing and R&D share in success (and do not blame the other for failure)

The vast majority of U.S. firms are organized by function. Functional organizations inherently violate the characteristics of Table 5. Functional organizations do not encourage or value cooperation across functions, nor do they lead to harmonious operations across functions where conflicts are resolved early and people work together. Formalization is disjointed. Performance standards across groups often conflict, as do responsibility designations for many of the cross-functional tasks and reward systems. Information and decision-making is functionally centralized rather than distributed to persons who have the knowledge to resolve cross-functional issues. Early research on the R&D/marketing interface suggested that effective integration was achieved by having a formally appointed "integrator" manage the project [108]. Top management appointed this manager who was then responsible for linking R&D and marketing and for the ultimate success of the project. This integrator is reminiscent of the "heavy-weight project leader" structure recommended by [14] and implemented by Chrysler [67] for managing product development teams in the automobile industry.

Another organizational solution to managing more smoothly the marketing/R&D interface is to promote dyadic relationships between particular R&D and marketing people [102,105]. Management assigns an R&D person and a marketing person joint responsibility for a project and provides them with significant autonomy. Dyad participants can become intensely committed to each other, creating successful innovations as a result of their joint commitment. According to [105], dyad relationships encourage innovation not only between the direct participants, but also can catalyze and institutionalize longer term interactions between other R&D and marketing participants.

More recently three organizational structures, coordinating groups, matrix organizations, and project teams, have been championed as more conducive for increasing cooperation than relying on a single integrator. Reviews of these organizational structures, their benefits and drawbacks, can be found in [25, 109,114].

Coordinating Groups. Permanent coordinating groups created to manage the cross-functional flow of new-product development have been advocated by [58,65,102,105]. Permanent coordinating groups consist of personnel who have a balanced perspective, which enables them to work effectively with several specialist groups over a long period of time to both facilitate and monitor progress. In case-based research,

Lorsch and Lawrence [65] found that coordinating groups produce higher firm-level performance (in terms of marketplace success and profits) where the uncertainty in at least one of the two dimensions (market or technology) is extremely high. They found that these groups integrate by providing a means by which conflicts are resolved and decisions are made, mediating the differences in organizational responsibilities between the two groups. The stability of the group allows them to learn the language of technologists and marketers; they act as translators across the functions. This research suggests:

Coordinating groups achieve higher market success and profit levels by overcoming language and organizational responsibility barriers, allowing better decisions to be made, and resolving conflicts. Their stability can reduce one dimension of uncertainty in extremely unpredictable environments.

Matrix Organizations. A number of firms have implemented matrix organizations in an attempt to maintain functional specialization while improving cross-functional integration [7]. Functional specialists reside in functional groups and report to a functional manager. They retain the ability to stay connected to the new frontiers in their technical area. They also report on a "dotted-line" to project leaders, frequently part-time, who need their particular expertise during a phase of a project. The matrix structure allows organizations to adapt to the needs of a project by flexibly manipulating group composition and expertise [12]. In theory, the project leader performs the integrating function by encouraging information exchange, providing formal reporting procedures and joint rewards, and assigning value to cooperation. The project leader is a temporary coordinator.

Case studies [34] and advocacy pieces [112] provide some evidence of the cost and effectiveness of matrix structures. One of the few large empirical studies published [63] found that firms using matrix organizations had product-development market success rates about twice the success rates found in functional organizations. How those success rates were achieved remains to be investigated. Thus, an important research hypothesis is:

Matrix organizations increase product-development success by reducing differences between functional responsibilities while increasing the amount of information available during a development project and enabling processes to be followed that lead to completed tasks.

In organizations with matrix structures, personnel often find it difficult to balance time spent in a functional group with time spent on projects. Individuals may infer different priorities from their functional and cross-functional managers, resulting in confusion. When balance between project and functional tasks is not maintained consistently across managers, matrix organizations run the risk of becoming just "paper" matrices [87].

Project Teams. As long ago as 1965, Marquis and Straight advocated placing all functional contributors on the same product-development project under a single leader [69]. Since then, other researchers have advocated similar solutions to managing the R&D/marketing interface, referring to the structures by a number of terms: tasks forces [102,105], product development committees, and most frequently cross-functional teams. Pulling some of the organization into cross-functional teams avoids the confusion of placing the entire organization into a matrix structure just to obtain the cross-functional integration required for some tasks. Recent research cites this mechanism as a major contributor to improved market success, profit generation, and/or reduced development cycle time [15,56,62,71,90,97,115,117].

Project teams solve a number of integration problems. They encourage information exchange, provide a degree of formalization, and encourage cooperation by providing a forum in which conflicts are resolved directly without intervention from management [64]. Project organizations maximize coordination across functions and focus a group on a specific goal. By focusing on a specific goal, it is easier for the team to overcome individual functional thought worlds and create a shared world with its own language and routine [29].

Teams are not without drawbacks. One potential long-term flaw with project-based organizations is that, by removing specialists from their functional groups, these specialists interact less with colleagues in their own technical or market-based discipline. If the project duration is too long, the expertise and knowledge base of the team members erodes, especially when the technology base or market structure is changing rapidly [87]. A project structure led to higher R&D performance for short duration projects or in projects where technology was not changing rapidly [4]. Project teams were the organizational mechanism leading to higher firm-level new product performance in situations where there was moderate uncertainty in both the marketing and technology dimensions, but

extreme uncertainty in neither [65]. In a cross-industry study of 179 projects, using cross-functional teams for product-development correlates with shorter product-development cycle time [37]. Project structures correlate with higher commercial (market) success [105]. This evidence suggests that:

Cross-functional project-development teams lead to higher marketplace success and shorter times to market decreasing the barriers of functionally specialized thought worlds, languages, and organizational responsibilities, and providing a forum in which information is utilized better, decisions are made more effectively, and conflicts are resolved.

However, research also implies that teams do not solve all of product development's marketing/R&D integration problems. In particular teams do not, in and of themselves, reduce technical or market uncertainty. Other mechanisms, such as technical problem-solving, experimentation, market research, and testing must be used to reduce uncertainties. Teams do not overcome personality differences and physical separation. They don't necessarily increase the amount of information available, even though they encourage better utilization of information already available among developers. Finally, teams don't ensure that the tasks of product development are accomplished.

Many companies using a project-team structure still have problems developing successful products efficiently and effectively. In some firms teams do not address all barriers and aspects of integration. Other mechanisms must be adopted to complement the teams. In other firms problems arise because teams frequently are implemented poorly resulting in suboptimal performance [55]. 3M found that keys to successfully using teams for product development included how they managed team selection, training, performance evaluation, motivation, project sponsorship, and the role of middle management [56]. Unless they carefully managed each of these aspects of implementing teams, the team had a lower probability of operating effectively. Characteristics of team members and the team leader affect project success and cycle time [70]. Even the choice of which functions to involve during which aspect of development impacts success by affecting directly how much information is available [88]. The way the team manages its internal processes [55,80,88] as well as its boundaries and relationships with people outside the team [6] affect performance and cycle time. Opportunities abound for research on the variables related to commissioning, man-

aging, operating, rewarding, and disbanding cross-functional product-development teams. More research is needed on the relationship between cross-functional teams and product-development success.

Summary. Coordinating groups, matrix organizations, and project teams have the potential to improve marketing/R&D coordination and communication; each has worked in a variety of circumstances. However, there is evidence that these organizational vehicles do not work in all situations. Because of the remaining barriers, uncertainties, and integrating tasks, an organizational structure may not be sufficient to generate adequate cooperation and communication. It must be supported by other means such as personnel co-location, moving personnel across functions, and formal integrative management processes.

Incentives and Rewards

In today's organizations, marketing and R&D personnel are evaluated most frequently on individual functionally based performance [17]. Only 7.4% of 189 responding companies tie compensation to successful performance of new products [81]. Marketing personnel frequently receive bonuses based on increases in market share, regardless of the reason share increased [59]. R&D, on the other hand, often receives bonuses based on evidence of technology improvement such as patents and publications, whether or not the new technology has led to better performing products or improvements in market share [113,118]. The current reward structures lead to differing organizational responsibilities across the functions, creating a barrier to effective integration, even though research published in 1978 demonstrated that firms implementing joint reward systems in which R&D and marketing share equally in the rewards from a successfully commercialized product is a very effective integrating mechanism.

Because individual performance objectives do not reflect the interdependence required of the product-development task, they can discourage the very efforts necessary to develop successfully new products [27]. These differing priorities may also mean that engineering prefers and champions projects that are not just different from those preferred by marketing, but whose goal is actually the reverse of the projects on which marketing would choose to work [48]. Neither department's project preferences may align with the firm's goal of maximizing profits.

Compensation researchers [17], new-product consultants [62], and marketing academics [52] have suggested changing the firm's reward systems to compensate employees from different functions based on eventual profits (or a current value indicator thereof) from the new product under development. These reward systems align responsibilities and thus increase overall firm profits. Partial support has been demonstrated for these recommendations. Compensating sales people on profits leads to increased profitability for the firms [8]. R&D team-based compensation was more effective than individual incentives in increasing overall project performance [35].

A simulated experiment with MBA students playing marketing and R&D roles found that creating interdependence in rewards increased expected firm profit in functional dyads [48]. However, this experiment also illustrated that when an incentive structure became too complicated, it was difficult to understand what decisions achieved the appropriate objective(s).

A more theoretical approach uses agency theory to investigate the interdependencies between upstream (R&D) and downstream (product-development) teams and to examine whether internal customer satisfaction systems might achieve integration [53]. According to the theory developed, two incentive systems, a profit-sharing system and a target-value system, can motivate both the upstream and the downstream agents, acting in their own best interests, to choose the efforts and capital that maximize firm's profits. In the profit-sharing system the downstream team decides what weight to place on a fixed bonus versus a bonus based on outcomes (satisfaction, sales, profit). If the downstream team chooses a larger weight, the upstream team is given a larger bonus. In the target value system, the downstream team selects its own outcome targets and receives a bonus that is maximized if it hits those targets. The upstream team's bonus depends upon the target that the downstream team selects. However, there is an important caveat to the reward systems. The firm must allow gainsharing between the teams or the system collapses. Through examples, these researchers argue that limited gainsharing is common in such upstream/downstream dyads.

Based on the research complete to date, we postulate:

Performance evaluations, which recognize the inter-related rewards to marketing and R&D, based on ultimate product-development profits (or indicators thereof) decrease the inherent barriers between the functions due to differing organizational responsibili-

ties and lead to increased profits by encouraging cross-functional decision-making and task completion and by providing incentives for resolving conflicts between the two functions.

Formal Integrative Management Processes

A number of firms still rely upon product-development artisans, people who "just seem to know what needs to be done." The firm empowers them to do the job, then works hard to stay out of their way [28]. An alternative means for managing product development is to use a formal management process which specifies what tasks are completed in what order by whom. This clarifies the decision authority [104]. Some research has shown that using a formal process can lead to improved development outcomes. Implementing a formal development process can eliminate significant time from the development cycle [36,37]. Firms that follow more complete processes develop more successful products [24].

Development groups in companies without formal development processes, or that don't follow their firm's process, "fly by the seat of their pants" or "do what we always have done" and hope that none of the details get lost along the way. Some firms without formal processes, or with poorly implemented processes select project leaders with a proven track record of developing successful products. These successful developers may have internalized a process that allows them to get products to market successfully.

Early research on integrated R&D and marketing group decision-making processes for single decisions demonstrated that cycling between nominal and interactive settings where the interactions are led by "effective integrators" (what in current language would be termed process facilitators) yielded the highest levels of both group consensus and integration [100]. In nominal settings, group members perform tasks individually, moving forward viewpoints but not engaging in any socioemotional conflict with others in the group. Facilitated interactive sessions provide forums for information exchange, personal value modification, and team building. Cycling between periods of introspective individual activity and facilitated interaction balance the need to stimulate exchange and resolve conflict while still providing havens into which participants can retreat to reflect on and internalize new learnings and value changes.

Recently, product-development processes have been developed that combine the inputs of marketing,

R&D, and even manufacturing into an integrated joint decision-making process that extends throughout the development cycle. Field research on 35 projects concluded that an ideal product-development process for facilitating ongoing joint decision-making [38]:

- structures decision-making processes across functional groups,
- builds a solidly-organized, highly-motivated team, and
- moves information for decision-making efficiently from its origin to the ultimate user.

Creating harmony between marketing and R&D groups is facilitated by formally structuring decision-making processes between them [105]. Integrated development processes may enhance communication and reduce barriers to cooperation [54,111]. This section reviews the effects of product-development processes on outcomes, starting with simple, functionally isolated processes that are less effective and moving on to improved, integrated versions that are more effective and that incorporate cycling between individual and group tasks as recommended in [100].

Phase-Review Processes. Typically, when a formal process for developing new products has been used, it has been a phased or sequential approach sometimes referred to as a phase-review process [90]. A defined set of tasks is completed by one or more people, usually all from the same function. The results are reviewed by management and a go or no-go decision is made. If progress on the project is approved, additional funding is appropriated and the next set of development tasks are begun, most usually by employees from a functional area different from those who completed the work in the previous phase. Leadership and group membership change phase by phase. In each phase, the new team must first get up to speed on what happened in the previous phase and learn why the project has evolved as it has.

Formal phased processes for product development do not overcome any of the barriers between functions because they maintain the functions in their isolated situations. For example, phase-review processes reduce time, but only by 25%–35% rather than the 50%–75% that firms appear to believe is possible [36]. However, phase-review processes do help ensure that tasks are completed which, in turn, leads to uncertainty reductions.

Following a *phase-review process* increases product success and decreases development time by ensuring

that necessary tasks are completed during development. This allows the reduction of project uncertainties.

One suggested incremental improvement to the phase-review process is to overlap problem solving by starting the next phase in the process before the current phase is completed [54]. Preliminary information is transferred as it becomes available with the codicil that the upstream group reserves the right to make changes as more is known. Development time is reduced as the downstream teams start their work earlier, compressing the critical path. Unfortunately, unless mechanisms are put in place to modify information flow so that it moves from group to group throughout a phase rather than just at the end, nothing changes operationally. Although personnel are assigned earlier to subsequent tasks, they only start tasks if information is actually available. If no mechanism is adopted by which early information gets transferred, no information is available and tasks do not actually commence. Because development work proceeds on the basis of preliminary information, more design rework is required, especially in projects with high uncertainty (market or technology) levels. Overlapping phases is more useful for projects with low to moderate uncertainty levels, as are found in the automotive industries from which this improvement was derived [54].

Stage-Gate Processes. The stage-gate systems follow the phase completion and review format of phase-review processes. However, rather than isolating tasks by function, stage-gate projects are completed using simultaneous participation by people from multiple functions. The stage-gate processes schedule tasks across all functional areas to minimize the critical path and to decrease the amount of engineering rework because of unknown downstream factors. Early involvement of all parties increases appreciation of the contributions of other functional areas and trust between them [105], which in turn increases profits derived from the products and decreases development time [22].

In phase-review processes, manufacturing engineers are not apprised of project details until late in development. They have no impact on specification setting or other up-front tasks. Often they are handed a product to commercialize that is not manufacturable. After tests and trials to prove their inability to manufacture the product, the whole project returns to the engineering design phase where a more manufacturable prod-

uct is created (sometimes at the expense of delivering product requirements) and brought to market "late."

In stage-gate systems, more activities are completed in parallel rather than sequentially [22]. For instance, in a preliminary assessment phase of a stage-gate system, manufacturing engineers investigate the manufacturability of concepts simultaneously generated by the development engineers. Prior to actual development, they must "sign off" that the concept, which proceeds through this gate, is probably manufacturable. Each function is responsible for completing one or more tasks in each stage before the project passes the gate and moves to the next stage. This ensures that no function can ascribe later performance failure to a different function—each function had a hand in getting the project through the gate. A testable hypothesis about stage-gate is:

Stage-Gate processes increase product success and decrease development time because they decrease integration barriers due to differing organizational responsibilities across functions. They also encourage task completion and decision-making, allowing the technical and market uncertainties of projects to be reduced.

Stage-Gate was conceived as a means for managing more effectively a single project. It defines a standard development framework of tasks requiring cross-functional participation which can be applied across the entire organization. There is some evidence that stage-gate improves the product-development process [22].

However, by itself, stage-gate does not solve all a firm's product-development problems. The project focus of the stage-gate process makes it difficult to implement successfully across the firm in some consistent form. Process customization and maintenance, process training, and a process-management superstructure are necessary for a large firm to implement and manage a stage-gate product-development process [80]. These tasks are not covered by the stage-gate system, per se, but must be provided by some other mechanism within the firm for stage-gate processes to provide the maximum benefit over the long-term.

PACE: Product and Cycle-time Excellence. Product and cycle-time excellence (PACE), described in [71], is a facilitator-implemented stage-gate process. This facilitated process furnishes consistent cross-company process and facilitator training, project implementation and management, and a superstructure for managing product-development resources across the portfolio of projects (cross-project management).

In the PACE system, a permanent coordinating group of process facilitators administers a structured phase-review development consistently across all business groups within the firm. At the outset, this facilitating group is supplied by outside consultants. Over time, internal facilitators are trained to take over the administration function. This centralized group builds and maintains the process expertise, including knowledge of all development tools and integration mechanisms. The developers claim that PACE increases profits and marketplace success and decreases product development cycle time, and they present anecdotal evidence to support their claims, using individual projects at specific companies. However, further research is needed.

Quality Function Deployment (QFD). QFD was developed in 1972 at Mitsubishi's Kobe shipyard, brought to the United States by Ford and Xerox in 1986 and, in the last 10 years, has been adopted widely by both Japanese and U.S. firms. QFD is now the seventh most frequently used marketing research technique in the United States [68], and it is cited as "one of Japan's most potent tools" [77]. In some Japanese applications it has reduced design time by 40% and design costs by 60% while enhancing design quality [51]. [50] and [89] provide case examples. For more detailed reviews, see [1,2,9,39,60,61,110].

QFD provides procedures to enhance communication and structure decision-making between marketing and R&D [38]. It provides a translation mechanism from the language of the customer to the language of the engineer by explicitly linking the two kinds of information in a "house of quality" (HOQ). This translation mechanism overcomes many marketing/R&D barriers. U.S. firms using QFD also claim that it has improved relations between marketing and R&D by focusing efforts on identifying and providing the information needed for designing products and services that satisfy customer needs [38].

Marketing and R&D participate as equal partners in building the HOQ, gaining a mutual understanding of the problem and of one another. The HOQ encourages cooperation between marketing and R&D by requiring each functional group to quantify and articulate their inputs and assumptions. Whereas customers are the primary sources of the marketing inputs to the HOQ, engineers provide the bulk of the technical and performance inputs. By specifying both languages and the means to translate one to another (relationship matrix), the HOQ prevents misunderstanding and forces each group to clarify their own thought world.

QFD's effect on product-development communications was compared to a traditional process in a quasi-experiment at a large car manufacturer [40] following a method developed by [3]. One development team used QFD; the other a phase-review process. QFD led to more communication, more communication within functions, and more communication between functions. However, QFD slightly reduced communication from the core team (marketing, R&D, manufacturing) to management. Examining communication in more detail suggested that QFD team members communicated directly to one another rather than going through a management loop. If management was serving primarily as a communication conduit, then this would imply that the QFD pattern of communication was more efficient. Experience by industry suggests that such communication gains are typical.

The philosophy of QFD is one of incremental improvements with payoffs coming over the long-term. However, many U.S. managers have promoted QFD based on the potential for immediately decreasing design costs and time to market. To determine whether QFD could provide benefits to U.S. firms, 35 QFD projects were studied at nine U.S. companies [38]. These projects included components, subsystems, and complex systems for products, services, and software. Although only eight (27%) of the 29 projects for which final results were available reported measurable improvements in speed to market or market success, 29 (83%) of the 35 projects ascribed other long-term strategic advantages to using QFD, advantages that warranted applying QFD to other projects in the firm. QFD may be better at providing (perceived) long-term rather than short-term benefits to the firm; firms should guard against asking too much too soon from QFD. To study QFD further:

Quality function deployment reduces the marketing/R&D barriers of different thought-worlds, languages, and organizational responsibilities and provides mechanisms to increase information utilization across the functions as well as resolving conflict between them. The processes used to build the HOQ lead to reduced market uncertainties. These improvements may lead to increased market success, but the results are more likely to be felt over the longer term rather than in QFD's first application at a firm.

Summary. A simple phase-review process improves a subset of the factors that affect the marketing/R&D interface. As the complexity of the development process increases from a phase-review process

to stage-gate and/or PACE, the number of affected interface factors increases and the outcome dimensions improve. Each improvement to the phase-review process results from coupling additional integrating mechanisms to a formal process. Stage-gate adds a cross-functional team (and reorganizes the order of some steps). PACE adds a permanent coordinating group. QFD provides an information structure in which the cross-functional teams operate. These additions improve the operation of the marketing/R&D interface; however, they do so at the expense of increasing the overall complexity of managing the product-development process. The development process used should match the complexity and degree of innovativeness of the project and should be framed in such a way as to legitimize its use [30].

Summary

Product development is pervasive and critical to long-term profitability in a variety of industries. Marketing plays an important role in product development by, among other things, providing information on customer needs and by participating in decisions on product positioning and feature delivery. We believe that marketing's role in the product-development process is a fertile ground for research and a fertile area for improved practice. Furthermore, by improving knowledge and practice in this area we should be able to make R&D's role more effective.

This article's goal has been to review published research and provide a structure and hypotheses for advancing the state of the art. Research in the fields of product development, technology management, R&D management, organization, and marketing each provide valuable perspectives to help understand the researchable issues relating to integrating mechanisms for marketing and R&D.

Research to date helps us understand that cooperation, when it occurs, often leads to success. The research has identified barriers to communication and cooperation including personality, cultural thought worlds, language, organizational responsibilities, and physical barriers. This research suggests methods to overcome these barriers and achieve functional integration. These methods include relocation and physical facilities design, personnel movement, informal social systems, organizational structures, incentives and rewards, and formal management processes. Although much is known, much remains to be studied. We hope

that this review and analysis of the literature on the marketing/R&D interface motivates many researchers to enter this important field.

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