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New Product Development Processes and New Product Profitability: Exploring the Mediating Role of Speed to Market and Product Quality

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In new product development, faster is not always better. Conceptually, being faster to market should improve financial performance by improving product quality and reducing development expenses. Empirical support is mixed, however, demonstrating that higher speed to market exhibits an inverted U-shaped relationship with product profitability. Conventional wisdom and empirical research suggest managers make speed to market–product quality–development expense trade-offs.

A particular concern regarding speed to market is that extreme speed may jeopardize product quality. Some researchers suggest that speed to market improves product quality while others suggest firms must balance both speed to market and product quality. Also, shorter lead times may be associated with reduced development expenses, but empirical evidence is conflicting.

This research attempts to reconcile conflicting results regarding the speed to market–product quality relationship, their joint impact on product profitability, and their mediation role in the effects of development expenses and cross-functional integration on product profitability. Partial least squares (PLS) is used to analyze multiplexed archival and survey data collected from NPD managers for 1115 different NPD projects in several firms. The results support the hypothesized equations, explaining 27% of speed to market variance, 35% of product quality variance, and 45% of product profitability variance.

This study makes two contributions. First, because speed to market and product quality are related, simultaneous consideration of both factors enhances insight into their joint effect. Second, it provides evidence that speed to market and product quality jointly mediate development expense by NPD phase and cross-functional integration effects on product profitability.

Key results from the large sample data analysis include the following. Speed to market and product quality both enhance product profitability, but the impact of speed to market is larger than that of product quality. Speed to market and product quality partially mediate the impact of fuzzy front end phase expenses on product profitability, while expenses in the latter phases exhibit no impact on the mediators or profitability. Thus, the results suggest that trade-offs are made not only between time, quality, and expense (i.e., if additional expenses are incurred at all), but also that trade-offs relate to when (i.e., in which NPD phase) additional development expenses are incurred. Finally, cross-functional integration (both internal and external) substantially impacts product profitability through a mix of direct and mediated effects.

Introduction

In today's competitive marketplace, product innovation is ever more appreciated as a key component of sustainable growth for most firms. A problem, however, is that new product development (NPD) is risky due to alarming failure rates and the large amounts of venture capital required (Cooper, Edgett, and Kleinschmidt, 2004). Identifying factors contributing to new product success remains a vital managerial concern, not only because successful new products are a major source of improved financial and market performance, but also because they may point to previously undiscovered business opportunities (Swink, 2000).

Among managers and academics alike it is widely accepted that three main factors impact NPD success: time, quality, and expense (Bayus, 1997; Clark and Fujimoto, 1991; Kessler and Chakrabarti, 1996; Smith and Reinertsen, 1998). Speed to market, also referred to

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as development cycle time, is the time between idea generation and new product launch (Griffin, 1993). Product quality refers to customer perceptions of superiority relative to competing alternatives (Sethi, 2000). Development expense is the level of resources required for a project to advance from concept creation to commercial product (Clark and Fujimoto, 1991). Meta-analyses suggest product quality (i.e., product advantage and meeting customer needs) is the most important factor of the three, followed by time considerations (i.e., speed to market, order of entry, and reduced cycle time) and R&D expenses (Henard and Szymanski, 2001; Montoya-Weiss and Calantone, 1994). While meta-analyses are useful for identifying overall associations between product financial performance and the independent variables of speed to market, product quality, and development expense, they generally do not test more complex relationships among the independent variables that arise when mediation is considered. Furthermore, there is scant empirical research simultaneously examining the impact of all three factors using data collected from a large sample of NPD projects from multiple firms (see Jayaram and Narasimhan [2007] for a notable exception).

This research intends to address this gap by modeling speed to market and product quality as mediators of the development expense–product profitability relationship. Development expense is modeled as an antecedent of speed to market and product quality because speed to market, technical performance (technical functionality and product quality), and product unit-cost objectives are set early in the project (Tatikonda and Rosenthal, 2000). However, resource allocations often are adjusted as projects proceed (Bayus, 1997; Cohen, Eliashberg, and Ho, 1996; Gerk and Qassim, 2008). Recent empirical research suggests development expense has the largest impact on product profitability and interacts with speed to market and product quality to positively impact profitability (Jayaram and Narasimhan, 2007). Employing a mediation approach offers the benefit of advancing understanding of how time, quality, and expense relate to each other and to product financial performance. Thus, this research specifically addresses the call for additional research assessing relationships among speed to market, product quality, development expense, and new product profitability (Langerak, Hultink, and Griffin, 2008).

In addition, the approach used here examines the impact of speed to market and product quality simultaneously. While speed to market is expected to improve product financial performance (Kessler and Chakrabarti, 1996), extreme speed may jeopardize product quality (Clark and Fujimoto, 1991). Success, therefore, requires firms to consider the impact of both speed to market and product quality (Clark and Fujimoto, 1991; Jayaram and Narasimhan, 2007). Because speed to market is associated with increasing product quality to a certain point after which quality levels begin to degrade, the speed to market–product quality relationship takes the shape of an inverted-U (Lukas and Menon, 2004). Thus, inefficiently organized projects benefit from increasing speed to market given its joint relationship with product quality, while projects organized in an efficient manner must trade off the benefits of increased speed and enhanced product quality (Swink, Talluri, and Pandejpong, 2006). In this article, the simultaneous effects of speed to market and product quality in a mediation model are examined empirically.

Finally, this research expands the literature by digging more deeply into the role of development expense and by accounting for the impact of cross-functional integration. Specifically, development expense effects are examined during four different phases of the NPD process, thus identifying when and how development expenses contribute to profit. Cross-functional integration is an element of integrated product development (IPD), a managerial approach to improve NPD performance through overlap and interaction of NPD activities (Gerwin and Barrowman, 2002). According to these researchers, "IPD has become *the* paradigm for NPD" (p. 938, emphasis in original). Cross-functional integration is included given its influential role in NPD project success (Clark and Fujimoto, 1991; Sanchez and Perez, 2003; Tessarolo, 2007). Other process variables, such as market orienta-

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tion, task proficiency, structured approach, and senior management support, also contribute to product success (Henard and Szymanski, 2001). They are not included due to the extensive attention they have received in the literature (e.g., market orientation) or their modest influence relative to the effects of other included process variables (e.g., structured approach).

This paper is organized as follows. First, the relevant literature relating to speed to market, product quality, development expense, and cross-functional integration in NPD is summarized. Second, the logic for the hypothesized model is explained. Subsequently, the research method, analysis, and results are described. Finally, the results including limitations, areas to be addressed in future research, and managerial implications are discussed.

Literature Review

Assessing how well new products perform in the marketplace occurs via several broad categories of metrics (Griffin and Page, 1993), including financial and nonfinancial measures (Page, 1993). An influential meta-analysis identifies performance categories as: (1) financial (i.e., profit, sales, pay back period, costs); (2) market-based (i.e., market share); and (3) technical (Montoya-Weiss and Calantone, 1994). This study examines financial NPD performance because financial success should be the ultimate goal of every firm. Among financial measures, profit, return on investment (ROI), and sales often are used. Because mean correlations between predictor and outcome variables remain consistent across specific performance metrics (Henard and Szymanski, 2001), product profitability is as appropriate a performance metric as ROI or sales. Therefore, profitability is the financial NPD performance criterion used in this research.

Successful new product performance is influenced by a combination of multiple factors that include product, firm strategy, marketplace, and NPD process characteristics (Henard and Szymanski, 2001). The research described herein examines the product profitability impact of NPD process characteristics, particularly examining the relationships among speed to market, product quality, development expense, and cross-functional integration. Considerable research identifies these factors as important in managing NPD projects (Clark and Fujimoto, 1991; Griffin, 1997b; Henard and Szymanski, 2001; Jayaram and Narasimhan, 2007; Montoya-Weiss and Calantone, 1994; Smith and Reinertsen, 1998; Swink et al., 2006). An additional contribution of this research, beyond examining these four variables simultaneously in a large sample of projects across multiple firms, is that the impact of development expenses by NPD project phase also is examined.

Speed to market, also referred to as development cycle time or lead time, is the time elapsed between initial development of the product idea and ultimate commercialization (Clark and Fujimoto, 1991; Griffin, 1993; Kessler and Chakrabarti, 1996). Speed to market is an important concept in new product development because of the two ways in which it potentially improves product profitability: in relation to product quality and in relation to development expenses.

Speed to market may improve product profitability by increasing market acceptance. The sooner a firm can launch a new product, the more certainty in forecasting customer preferences and developing a product concept customers find attractive (Clark and Fujimoto, 1991; Kessler and Bierly, 2002). Product attractiveness, or product quality, is customer perception of the extent to which a product or service meets or exceeds their requirements relative to competing alternatives (Sethi, 2000). Product quality is known also as product superiority/uniqueness (Cooper, 1979), product advantage (Henard and Szymanski, 2001; Montoya-Weiss and Calantone, 1994), product performance (Bayus, 1997; Cohen et al., 1996; Swink et al., 2006), and total product quality (Clark and Fujimoto, 1991). Empirically, product quality plays a primary role in explaining product marketplace success (Clark and Fujimoto, 1991; Henard and Szymanski, 2001; Li and Calantone, 1998; Montoya-Weiss and Calantone, 1994; Song and Parry, 1996; Veldhuizen, Hultink, and Griffin, 2006). Product quality consists of two dimensions impacting customer perceptions: design quality, which is the extent to which the product design matches customer expectations, and conformance quality, which is the ability to produce the product per the design specifications (Clark and Fujimoto, 1991; Jayaram and Narasimhan, 2007).

Despite the uncertainty-reduction logic described above conceptually linking speed to market with improved product quality (Kessler and Chakrabarti, 1996), empirical results are mixed. Some researchers find a medium correlation between speed to market and product quality (Kessler and Bierly, 2002). However, others report the correlation is insignificant (Clark and Fujimoto, 1991), or the partial correlation is only minimally significant when controlling for development expense (Jayaram and Narasimhan, 2007). These conflicting results may arise because the relationship takes an inverted-U shape, where speed to market improves

product quality to a certain point after which quality levels begin to degrade (Lukas and Menon, 2004).

Speed to market and product quality together are significant predictors of firm performance (Ittner and Larcker, 1997), so clearly some minimal level of speed to market and product quality are necessary for market success (Clark and Fujimoto, 1991; Jayaram and Narasimhan, 2007). Clark and Fujimoto (1991) refer to the need for both speed to market and product quality as "balanced excellence," proposing that managers must make trade-offs between both requirements to be successful. Analytical models help managers make effective trade-off decisions and improve product profitability (Bayus, 1997; Cohen et al., 1996). Empirical research not only demonstrates that managers do indeed make speed to market–product quality trade-offs, but also that different trade-off arrangements (emphasizing speed, quality, or expense) are equally successful among highly efficient project groups (Swink et al., 2006).

The second way speed to market may improve product profitability is by reducing the amount of time available to spend development funds (Kessler and Chakrabarti, 1996). Essentially, shorter lead times may be associated with reduced development expenses, defined as resource levels allocated to advance a project from concept creation to commercial product (Clark and Fujimoto, 1991). While development equipment, development services, and prototype materials also comprise development expenses, these expenditures tend to be overwhelmed by the total time and wages invested in the project.

Empirical research finds both positive and negative relationships between speed to market and development expenses. Some empirical research finds a positive correlation (Clark and Fujimoto, 1991; Datar et al., 1997; Swink et al., 2006), while other research finds a negative correlation in that product introduction delays are associated with lost revenue and increased R&D expenses (Hendricks and Singhal, 2008). However, speed to market may result from "crashing" the NPD project by allocating more resources than had been planned originally (Gerk and Qassim, 2008), which involves higher development expenses as both headcount and coordination expenses grow (Bayus, 1997; Cohen et al., 1996). Analytical models account for these conflicting results by modeling speed to market and development expenses as a U-shaped relationship (Bayus, 1997; Cohen et al., 1996).

Speed to market–development expense relationships assume some unspecified level of constant product quality (Pollack-Johnson and Liberatore, 2006). Thus, product quality can be modeled by including multiple speed to market–development expense curves for various quality levels, incorporating the existing trade-off between the remaining two variables when one is held constant. Empirical results conflict regarding the development expense–product quality relationship. Some empirical works find no significant correlation (Clark and Fujimoto, 1991; Kessler and Bierly, 2002). However, Swink and colleagues (2006) find that higher development expenses are associated with higher manufacturability and lower defects (i.e., conformance quality), as well as higher product performance and better meeting specific customer needs (i.e., design quality).

Yet to be investigated, however, is how development expenses by NPD process phase are related to speed to market, product quality, and product profitability. This research follows Griffin (1997a) by grouping the stages at a more aggregate level of four phases that comprise similar activities in terms of the extent of information available and the types of decisions addressed. The four phases examined here are: fuzzy front end, product development, prototype building and testing, and manufacturing set-up and market launch.

Cross-functional integration is the extent of unity of effort across functional areas in developing and launching a new product (Song and Parry, 1997a). Cross-functional integration is an element of integrated product development (IPD), a managerial approach to improve NPD performance that is quite influential (Gerwin and Barrowman, 2002). Given its importance, the model also examines the mediation role of speed to market and product quality in the cross-functional integration–product profitability relationship.

Model Development

The conceptual model and hypothesized paths are depicted in Figure 1. Next, the logic supporting speed to market and product quality as mediators between the antecedents of development phase expenses and cross-functional integration and the dependent variable of product profitability is explained.

Speed and Quality Mediate Development Phase Expenses-Profit Association

As discussed previously, this research examines the impact of development expenses in the following four NPD process phases: fuzzy front end, product development, prototype building and testing, and manufacturing set-up and market launch. The fuzzy front end encompasses all activities occurring prior to NPD execution where market requirements, technology choices, and

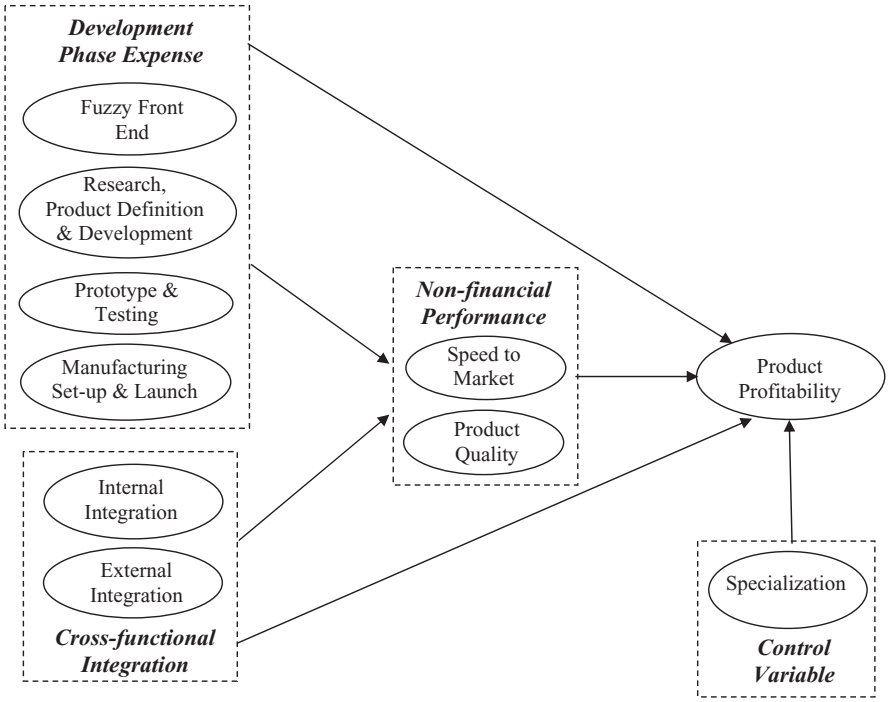

Figure 1. The Conceptual Mediation Model

other project-related decisions are proposed, considered, and traded off (Khurana and Rosenthal, 1998). The result is a formal or informal statement of product requirements, technology choices, and project objectives (Tatikonda and Rosenthal, 2000), which guides product design priorities so that subsequent decision makers can efficiently create quality products (Bacon, Beckman, Mowery, and Wilson, 1994). Formal product concept definition and concept testing have no impact on speed to market while formal definition and approval of the preliminary design (i.e., technical specifications, target performances, architecture, and component choices) negatively impact speed to market (Filippini, Salmaso, and Tessarolo, 2004). Supporting the positive relationship between fuzzy front end investments and product quality is research examining criteria managers use to evaluate if projects warrant advancement to the next phase. Design quality–related decision criteria (product uniqueness and technical feasibility) and product profitability are important in fuzzy front end evaluation metrics, while speed to market receives minimal consideration (Tzokas, Hultink, and Hart, 2004). Also, investments in front-end activities increase product advantage and profitability (Song and Parry, 1997a; Veldhuizen et al., 2006).

Product development is the phase in which the new product is designed and developed (Cooper, 1993). Expenditures in this phase are positively associated with speed to market (Datar et al., 1997), product quality (Lukas and Menon, 2004; MacCormack, Verganti, and Iansiti, 2001), and profitability (Henard and Szymanski, 2001; Langerak and Hultink, 2006). For highly complex projects, expenses in this phase result not only from headcount but also from the use of specialists and from project manager oversight (Bajaj, Kekre, and Srinivasan, 2004). Specialists reduce development expenses and shorten development, while additional project manager oversight lengthens the development phase. At the same time, however, both development phase expenses and time are negatively associated with manufacturing phase expenses and time, respectively. Thus, development expenses support speed to market in their association with shorter manufacturing phases while at the same time contributing to reduced manufacturing expenses.

The prototype building and testing phase encompasses tests or trials conducted in the marketplace, development laboratories, and manufacturing facilities to verify and validate the product and its marketing and production (Cooper, 1993). Development expenses do not impact the elapsed time to prototype completion (Datar et al., 1997). However, longer time to prototype completion results in shorter time to volume production and faster overall speed to market. Therefore, expenses allocated to prototype building and testing increase speed to market, particularly when customer feedback is sought (Datar et al., 1997; Filippini et al., 2004). In this phase, managers rely most heavily on conformance quality-related decision

criteria (product performance and quality) in deciding if advancing to the next NPD phase is warranted, with minimal consideration of speed to market and product profitability (Tzokas et al., 2004). For example, software developers use prototypes to improve communication with users (Khalifa and Verner, 2000), which should enhance design quality. When the competitive environment for software products is uncertain and dynamic, product quality increases through early prototyping to gain market and technical feedback (MacCormack et al., 2001).

Manufacturing set-up and market launch is the final phase where the new product is commercialized and full production, marketing, and selling occurs (Cooper, 1993). Product quality is affected by both objective attributes (e.g., performance to functional specifications) and less tangible ones (e.g., image, usage experience). Customers often are uncertain about the level of less tangible attributes before using a new product, so manufacturers use price and advertising relating to the less tangible attributes to signal product quality (Thomas, Shane, and Weigelt, 1998). Investments in launch activities (i.e., promotion, distribution, branding, and entry timing) positively influence customers' product advantage perceptions, enhance diffusion through the market, and increase product profitability (Guiltinan, 1999; Hsieh, Tsai, and Wang, 2008; Langerak, Hultink, and Robben, 2004a). Thus, a key contingency in successful market launch relates to the extent and type of firm resources allocated to these efforts.

In summary, extant literature suggests product development expenses impact product profitability directly and indirectly through speed to market and product quality. However, the specific effects are expected to vary by NPD phase. Therefore:

H1: The effect of product development expense by NPD phase on product profitability is mediated by (a) speed to market and (b) product quality.

Speed and Quality Mediate Cross-Functional Integration-Profit Association

Cross-functional integration is comprised of two integration forms: internal integration and external integration. Internal integration is strong power/influence and wide responsibility of NPD team members, particularly the product manager who acts as the full-time project coordinator (Clark and Fujimoto, 1991). Internal integration suggests there is a strong product manager coordinating the project and communicating the product concept to all those on the NPD team. Effective coordination within the project team is the objective of internal integration. Cross-functional representation often is used to achieve coordination because it broadens the project team's knowledge base and encourages idea cross-fertilization while at the same time providing greater flexibility to respond to problems (Kessler and Chakrabarti, 1996). However, recent empirical research finds that cross-functional representation reduces development speed and has no direct effect on product profitability (Langerak and Hultink, 2005). Internal integration comprises both cross-functional representation and product vision, which is a clear product concept and sharing of the product concept with the NPD team (Tessarolo, 2007). Although Tessarolo (2007) finds a negative relationship of internal integration with speed to market, he finds a positive relationship of the cross-functional representation-product vision interaction with speed to market. These empirical results suggest internal integration positively impacts speed to market and has no direct effect on product profitability.

Empirical results also suggest that internal integration and product quality are correlated significantly (Clark and Fujimoto, 1991; Hsieh et al., 2008). Research has examined the impact on product quality of two separate dimensions of internal integration: functional diversity, which is the number of functional areas with full-time team members, and information integration, which is team members sharing, paying attention to, and challenging one another's information and perspectives to generate new product insights (Sethi, 2000). The results suggest functional diversity is not significantly related with product quality, while information integration exhibits both a main effect and interaction effects on product quality. Thus, internal integration comprised of both information usage and functional diversity is associated with improved product quality.

External integration is strong power/influence and wide responsibility of marketers, customers, and suppliers (Clark and Fujimoto, 1991). External integration is concerned with matching the product to customer expectations through influential marketers, customers, and suppliers. The expected benefit of external integration is higher product quality, particularly related to design quality. Critical to effective NPD is the ability to simulate the target customers' future consumption experience so the product delivers important and differentiated benefits. When future customer needs are unpredictable and difficult to articulate, firms have the opportunity to create a competitive advantage if they can simulate future consumption experiences better than

the competition. Not only does the firm need to better anticipate the customers' entire usage experience, it also needs to develop a product concept that best meets these needs. Additionally, to enhance communication to all involved in the design, engineering, manufacturing, and promotion at each step of the NPD process, the product concept must be clear, as inaccuracy or vagueness can slow speed to market (Kessler and Chakrabarti, 1996). External integration suggests there is a strong concept champion who ensures deep product concept understanding to relevant parties who are not included in the NPD team, and has been linked with fast development and high total product quality (Clark and Fujimoto, 1991).

Tessarolo (2007) finds both a main effect of external integration and an interaction effect with product vision on speed to market. Langerak and Hultink (2005) report multiple results regarding external integration components: supplier involvement positively impacts development speed but not product profitability, customer emphasis positively impacts product profitability but not development speed, and lead user involvement positively impacts both development speed and product profitability. These results suggest that the impact of external integration on product profitability is at least partially mediated by speed to market.

Regarding product quality, Sethi (2000) finds a positive association between customers' influence (an element of external integration) and product quality. Nakata, Im, Park, and Young (2006) find that the relationship between external integration and new product performance is fully mediated by product quality in cultures reflecting centralized decision making such as Korea. Thus, empirical research suggests product quality mediates the relationship between external integration and product profitability. Therefore:

H2: The effect of cross-functional integration on product profitability is mediated by (a) speed to market and (b) product quality.

Now, the article turns to a discussion of the research method used to test the hypotheses.

Research Method

Data Collection

Data collection procedures mirrored the extant literature using secondary data from multiple projects or sites (e.g., Bajaj et al., 2004; Datar et al., 1997; MacCormack et al., 2001). Data were gathered for 1115 NPD projects undertaken by business units or divisions of seven U.S. firms from various industries. While the participating companies' identities and characteristics cannot be revealed due to strict confidentiality and anonymity agreements, all are very large conglomerates with over $1 billion in annual sales revenues. Data collection occurred while the firms were consulting clients of one of the co-authors or his/her consulting partners. The data collection approach combined archival secondary data compilation with survey responses to perceptual measures from key informants (those most knowledgeable about the NPD projects; Phillips, 1981). The key informants were senior product development managers intimately involved in the specific new product development projects on which they reported.

The survey took the form of a spreadsheet distributed by e-mail. Respondents were instructed to complete the spreadsheet for all products that had been launched within the five prior years and on which they were able to provide data. Survey items enabled recording of the secondary data respondents obtained from firm records regarding project stage duration and NPD project outcomes. Other items assessed the key informants' perceptions of integration and the control variable of specialization for each of these projects. Most responses were returned electronically, although missing data occasionally were retrieved via FAX. Data from a total of 453, 208, 213, 93, 73, 43, and 32 products were obtained from the seven firms, respectively. The largest data set ($n = 453$) comes from a firm where a consulting partner worked for nearly two years and the corporate library contained very detailed records in an electronic archive.

Measures

The extant NPD literature was reviewed to identify items to measure the constructs of interest. See Table 1 for a summary of the construct operationalizations. The dependent variable is product profitability, which often is used in the NPD literature to assess product performance (Griffin and Page, 1993; Montoya-Weiss and Calantone, 1994). As operationalized by Cooper (1979), product profitability was measured using a single item assessing product profit performance relative to the firm's objectives as documented in the firm records. A semantic scale is used for this item ranging from −3 "far below expectations" to +3 "far above expectations." At the mid-point, zero means that the targeted product profitability goal was exactly achieved. The use of a relative measure has specific advantages. First, it enables the researcher to

Table 1. Construct Operationalizations

Construct	Response Format	Data	Items
Product Profitability (Cooper, 1979)	−3 = far below expectations; +3 = far above expectations	Archival	Product profit relative to firm objectives as documented in firm records
Speed to Market (Clark and Fujimoto, 1991)	−3 = far below expectations; +3 = far above expectations	Archival	Number of months elapsed from concept to market launch relative to firm objectives as documented in firm records
Product Quality (Clark and Fujimoto, 1991)	−3 = far below expectations; +3 = far above expectations	Archival	Design quality (usefulness for intended purpose) and conformance quality (technical performance) relative to firm objectives for each as documented in firm records
Development Phase Expense (Clark and Fujimoto, 1991)	Person-months	Archival	Total person-months allocated to each phase as documented in firm records
Internal Integration (Clark and Fujimoto, 1991)	0 = strongly disagree; 10 = strongly agree	Key informant perceptions	1. Concept creators have strong influence over marketing decisions. 2. Concepts are created through cross-functional discussion under the leadership of concept creators. 3. Concept generation and product planning stages are merged. 4. Concept creators perform product planning. 5. Concept creators perform layout. 6. Simultaneous development of concept and styling. 7. Simultaneous development of layout, styling, and component choice.
External Integration (Clark and Fujimoto, 1991)	0 = strongly disagree; 10 = strongly agree	Key informant perceptions	1. Product managers are involved in product planning. 2. Product managers are responsible for layout. 3. Product managers are involved in concept generation. 4. Product managers have significant influence over product engineering. 5. Product managers maintain direct contact with working engineers. 6. Marketing liaisons have influence over working engineers. 7. Product managers have strong influence outside the engineering function. 8. Suppliers are integrated with development and engineering. 9. Product managers are responsible for wide development stages/areas. 10. Product managers maintain direct market contact.
Specialization (Calantone and Di Benedetto, 2000)	0 = strongly disagree; 10 = strongly agree	Key informant perceptions	For this innovation project: 1. there were many different specialized groups utilized. 2. a wide variety of different departments contributed to the final result. 3. we utilized many more specialists than on the usual innovation project.

Note: all raw data were standardized prior to analysis.

avoid problems in comparing actual values for different projects and products (Chryssochoidis and Wong, 2000). Second, this response format allows results to be compared across industries. Furthermore, since mean correlations between predictor and outcome variables do not vary with the specific metric for measuring performance (Henard and Szymanski, 2001), product profitability is as appropriate a performance measure as sales, ROI, and other measures.

The mediating outcomes in the model indicate the nonfinancial performance of the NPD project (Clark and Fujimoto, 1991). Both speed to market and product quality measurements follow the same approach as in the product profitability measure. Specifically, speed to market was measured using a single item comparing the number of months elapsed in taking the product from concept to market launch relative to the firm's objectives indicated in the firm's archival data. Product quality was measured using a two-item scale comparing the two quality dimensions of design (usefulness for the intended purpose) and conformance (technical performance) to the firm's objectives for each. Both of these variables were measured via a semantic scale ranging from −3 "far below expectations" to +3 "far above expectations." Similar to product profitability, employing relative measures enables comparability across projects. Moreover, it has an additional advantage in the mediation models in that the relative measures reflect the objective measures, thus minimizing measurement error.

Regarding the independent variables, development phase expense is measured as total person-months allocated to each phase of the NPD process (Clark and Fujimoto, 1991). First, data on eight different phases were collected from firm archives. To create variables for the four phases studied in this research, person-months were summed for design phases, as follows: fuzzy front end (FFE) encompasses idea screening, market and technology feasibility assessment, and marketing plan development; research, product definition, and development (RPD) encompasses product design and development; prototype and testing (PT) encompasses prototyping and trial tests; manufacturing set-up and launch (ML) encompasses the final two phases of full production and market launch.

The other set of independent variables assesses cross-functional integration in terms of internal integration and external integration, the two subdimensions of the integration index developed by Clark and Fujimoto (1991). The internal integration index is composed of seven items relating to the extent of engineering coordination, while the ten external integration items relate to the extent to which nonengineering functions, including concept developers, provide input into product development. Both internal integration and external integration scale items were measured by an 11-point Likert scale, anchored by 0 = strongly disagree and 10 = strongly agree.

The effect of specialization, which deals with the extent of individual expertise, on product profitability is examined by adding it as a control variable (Clark and Fujimoto, 1991). From an organizational perspective, degree of specialization determines how narrowly the organization is divided into departments and other subunits. A greater variety of specialists can bring a broader base of knowledge for managing the new product initiative and identifying and generating new product ideas (Henard and Szymanski, 2001). Specialization helps to accomplish highly specific tasks professionally and efficiently (Vandevelde and Dierdonck, 2003). However, a meta-analysis finds no relationship between specialization and speed to market (Gerwin and Barrowman, 2002). Because coordination problems arise when headcount gets large (Clark and Fujimoto, 1991), it becomes more difficult to communicate the product concept and design quality is sacrificed. Thus, not only do expenses increase with increasing specialization, but also it becomes more likely the product will lack sufficient differentiation to ensure attractiveness, and product profitability suffers. Given the multiple mechanisms through which specialization impacts product profitability and the insignificant empirical association with speed to market, the direct effect of specialization on product profitability is included as a control variable. Three items adapted from Calantone and Di Benedetto (2000) comprise the specialization scale, which was measured using an 11-point Likert-type response format anchored by 0 = strongly disagree and 10 = strongly agree.

All raw data were standardized prior to analysis. The three factors using multiple items (internal integration, external integration, and specialization) were standardized using factor scores resulting from a four-factor exploratory factor analysis. This standardization process had multiple objectives. First, measures were standardized to ensure project equivalence, which provides a simple way to compare across projects, firms, and industries. Most of the firms developed products in several lines of business and industries, so projects were not comparable even within one firm. Second, standardization helped eliminate respondents' differential usage of response anchor points. Moreover, standardization further supported the firms' requests for confidentiality. The internal integration, external integration, and specialization scales exhibited robust Cronbach's α reliabilities

Table 2. Descriptive Statistics and Correlations

	1	2	3	4	5	6	7	8	9	10
1. Product Profitability	1.000									
2. Speed to Market	.527**	1.000								
3. Product Quality	.608**	.726**	1.000							
4. Fuzzy Front End	.225**	.313**	.287**	1.000						
5. Res., Prod. Def., Dev.	−.079**	−.049	−.012	.018	1.000					
6. Proto Testing	−.034	−.079**	−.123**	−.192**	−.093**	1.000				
7. Mfg. Launch	.042	−.042	−.064*	−.187**	−.260**	.167**	1.000			
8. Internal Integration	.475**	.347**	.542**	.161**	.021	−.154**	.027	1.000		
9. External Integration	.436**	.135**	.462**	.078**	.204**	−.150**	−.028	.843**	1.000	
10. Specialization	.013	−.557**	−.022	−.206**	.006	−.049	.104**	.366**	.553**	1.000
Mean [a]	*4.00*	*4.00*	*4.00*	*8.00*	*8.00*	*8.00*	*8.00*	*4.00*	*4.00*	*4.00*
Std. Dev.	*1.00*	*1.00*	*1.00*	*1.43*	*1.39*	*1.28*	*1.32*	*1.00*	*1.00*	*1.00*

* significant at $p < 0.05$.
** significant at $p < 0.01$.
[a] Raw scale for product profitability, speed to market, and product quality ranges from −3 to +3. Raw scale for specialization and internal and external integration ranges from a low value of 0 to a high value of 10.

(above 0.70). See Table 2 for descriptive statistics, including means, standard deviations, and correlations.

Analysis and Results

Analyses were conducted at the project level to test whether the relationships between development phase expenses, cross-functional integration, and product profitability are mediated by the nonfinancial performance measures of speed to market and product quality. Analyzing at the project level is most directly relevant to understanding the impact of speed to market and product quality because it captures the unique situational attributes affecting actual projects (Kessler and Chakrabarti, 1996).

The data analysis procedure chosen is the structural equation modeling technique of partial least squares (PLS). PLS is an appropriate analysis technique because it allows multiple hypotheses to be tested simultaneously while also enabling single- and multi-item measurement and the use of formative scales (Fornell and Bookstein, 1982; Reinartz, Haenlein, and Henseler, 2009). Like other structural equation modeling (SEM) techniques, PLS combines principal component analysis, path analysis, and a set of regressions to generate estimates of standardized regression coefficients (beta values) for the model's paths and factor loadings for the measurement items. Thus, path coefficients, significance levels, and multiple R^2 values in a PLS structural model can be interpreted in the same way as standardized coefficients, significance levels, and R^2 values in a multiple regression (Hsu, Chen, and Hsieh, 2006). However, unlike other SEM techniques, PLS does not make assumptions about (a) the data distribution to estimate model parameters (Fornell and Larcker, 1981), (b) the independence of observations, and (c) variable metrics (Barclay, Higgins, and Thompson, 1995). PLS is robust in dealing with complex models due to its iterative algorithm (Henseler, Ringle, and Sinkovics, 2009), and simulations corroborate the robustness of PLS estimates under conditions of substantial factor correlations (Cassel, Hackl, and Westlund, 1999). Prior research in the extant NPD literature has employed PLS as the data analysis procedure (e.g., Howell and Shea, 2001).

Analysis results are summarized in Figure 2, which shows path coefficients and significance levels for significant paths only. The structural model explains 27.0%, 35.2%, and 45.0% of the variance in speed to market, product quality, and product profitability, respectively. Speed to market and product quality both are significantly associated with product profitability, with speed to market ($\beta = 0.44$) exhibiting a stronger effect than product quality ($\beta = 0.21$). In addition, speed to market and product quality exhibit mediation relationships between product profitability and at least one dimension within each independent variable, suggesting the mediation model is appropriate.

Regarding the independent variable of development phase expenses, only expenses incurred in the fuzzy front end (FFE) are associated with product profitability. FFE expenses exhibit a small but significant direct effect on product profitability ($\beta = 0.07$) and are associated with both speed to market ($\beta = 0.24$) and product quality ($\beta = 0.19$). Thus, Hypotheses 1a and 1b are partially supported in that speed to market and product quality partially mediate the relationship between FFE expenses and product profitability.

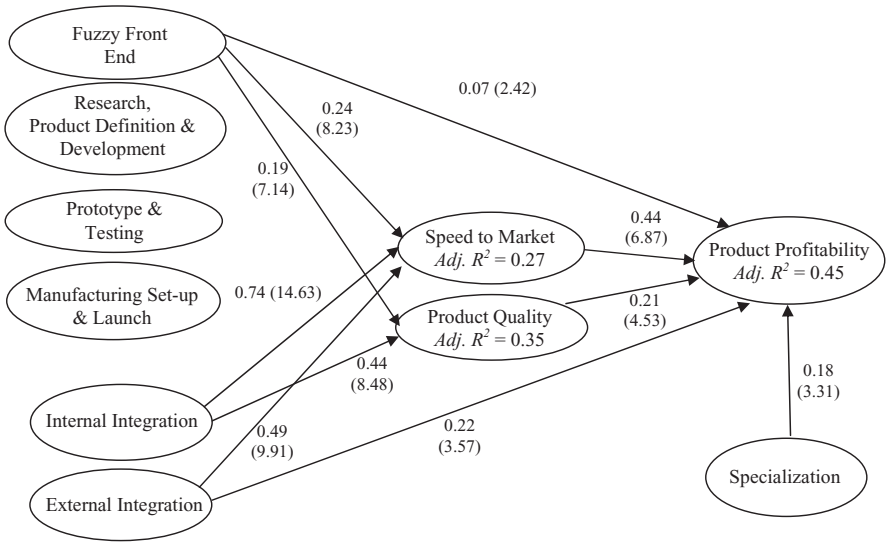

Figure 2. Results for the Hypothesized Model (significant paths; t-values in parentheses)

H2 suggests speed to market and product quality mediate the effect of cross-functional integration on product profitability. Internal integration is significantly associated with both mediators: $\beta = 0.74$ for speed to market and $\beta = 0.44$ for product quality. At the same time, internal integration exhibits no direct association with product profitability. Thus, the effect of internal integration on product profitability is fully mediated by speed to market and product quality. External integration, on the other hand, exhibits a direct association with product profitability ($\beta = 0.22$) and also is associated with speed to market ($\beta = 0.49$), while exhibiting no significant relationship with product quality. Therefore, the effect of external integration on product profitability is partially mediated by speed to market, suggesting full support for H2a and partial support for H2b.

Overall, the results in Figure 2 suggest speed to market and product quality jointly mediate the effects of development phase expenses and cross-functional integration on profitability. Only development expenses in the fuzzy front end impact profitability, directly and through both mediators. Both cross-functional integration forms are mediated by speed to market, while product quality does not mediate the external integration–product profitability relationship. Thus, speed to market exhibits a stronger mediation effect in that it exhibits a larger standardized regression coefficient than product quality and it also mediates for external integration while product quality does not. These results have valuable academic and managerial implications, as discussed in the next section.

Discussion and Implications

This research attempts to reconcile conflicting results regarding the speed to market–product quality relationship, their joint impact on product profitability, and their mediation role in the effects of development expenses and cross-functional integration on product profitability. Thus, this study makes two contributions. First, because speed to market and product quality are correlated, simultaneous consideration of both factors and their correlation enhances insight into their joint effect. Second, it provides evidence that speed to market and product quality jointly mediate fuzzy front end development expense and cross-functional integration effects on product profitability. Key results from the large sample data analysis are:

1. Mediators considered jointly:
   a. Speed to market and product quality enhance product profitability.
   b. Speed to market is more impactful than product quality on product profitability.

2. Development phase expenses:
   a. Only development expenses in the fuzzy front end impact speed to market, product quality, and product profitability.
   b. Both speed to market and product quality partially mediate the impact of fuzzy front end phase expenses on product profitability.

3. Cross-functional integration:
   a. Both internal integration and external integration substantially impact product profitability, with internal integration exhibiting the stronger effect.
   b. Both speed to market and product quality fully mediate the impact of internal integration on product profitability.
   c. The impact of external integration on product profitability is partially mediated by speed to market, while product quality plays no role in the impact of external integration.

Despite the important role of product quality (Henard and Szymanski, 2001; Montoya-Weiss and Calantone, 1994), the results indicate product quality is not as impactful on product profitability as speed to market. While surprising given meta-analysis results, managers often are disappointed in returns on product quality investments (Morgan and Vorhies, 2001). In addition, a substantial number of firms do not operate as efficiently as possible and can benefit from speed to market improvements (Smith and Reinertsen, 1998; Swink et al., 2006). The results suggest firms should focus first on increasing speed to market prior to investing in product quality improvements. At the same time, product quality supports both speed to market and product profitability and so should not be ignored.

Expenses associated with the fuzzy front end comprise the sole development phase expenses impacting product profitability, and the effect is partially mediated by speed to market and product quality. The influence of fuzzy front end expenses comes as no surprise given the extant literature emphasis on its conceptual importance (Reid and de Brentani, 2004) and empirical impact (Langerak, Hultink, and Robben, 2004b). The front end is influential because product advantage and compatibility are designed into the product from the beginning (Guiltinan, 1999). The ability to convert promising ideas into launched products is positively related to expertise (Chandy, Hopstaken, Narasimhan, and Prabhu, 2006), particularly in business and market opportunity analysis (Song and Parry, 1997a). Our results suggest, however, that front end activities impact profit independent of proficiency levels, and that the impact occurs primarily through faster speed to market and higher product quality.

Given the influence of product development, testing, and launch phase expenses detailed earlier in the hypotheses development section, the nonsignificant effects for these phases come as a surprise. However, the data set used in this research comprises secondary data from a broad set of projects across multiple firms. Survey self-reports using subjective responses inflate the influence of dedicated human resources while underestimating the impact of reduced cycle time on performance (Henard and Szymanski, 2001). Scant research examines the impact of development expenses by individual phase on speed to market and product quality, and none appears to examine the impact on product profitability. Results from archival data solely examine speed to market in electronic component projects (Datar et al., 1997) and product quality in software projects (MacCormack et al., 2001). The substantial size of the data set used herein, along with its composition of secondary data from many projects across multiple firms, provides confidence in the validity of the results. The negative correlation between development expenses and manufacturing and launch expenses, which aligns with advanced missile guidance systems archival data analysis results (Bajaj et al., 2004), further supports the findings.

Thus, the results suggest trade-offs are made not only between quality, time, and expenses (i.e., *if* additional expenses are incurred at all), but also trade-offs relate to *when* (i.e., in which NPD phase) additional development expenses are incurred. Here, expenses incurred in the earliest phase are more effective in driving product profit directly and by speeding time to market and enhancing product quality. Thus, the results caution against sacrificing early product development investments in the hopes of "catching up later."

Finally, the impact of internal integration on product profitability is fully mediated by speed to market and product quality. External integration, on the other hand, exhibits direct and indirect effects on profitability through speed to market, underscoring the need to consider joint and mediating effects among multiple NPD success dimensions. Furthermore, contrary to prior research conceptualizing integration in terms of team membership (Langerak and Hultink, 2005; Tessarolo 2007), the results indicate that information integration and team membership together exhibit a positive association with speed to market. In addition, this research builds upon prior research highlighting the role of information integration in product quality (Sethi, 2000) by demonstrating that information integration also positively impacts product profitability via product quality.

Overall, the results draw attention to the joint impact of speed to market and product quality. Furthermore, managers should concentrate their efforts on investing in the earliest development phase and increasing cross-functional integration, particularly within the NPD team.

Limitations and Future Research

As with all research, the results are subject to limitations. This research does not account for how the activities in

the development stages are organized in terms of whether they are performed sequentially or concurrently (Cohen et al., 1996). Also, specific functional groups involved in a project are not included. That is, development teams may comprise designers, component engineers, technicians, etc., while external representation can encompass customers, sales people, marketing, etc. Future research should account for the types of functions represented at various phases of the development effort.

In addition, the impact of development activity execution proficiency within each phase is not addressed despite its considerable explanatory power in other research (Henard and Szymanski, 2001). Clearly, execution proficiency matters in product quality (Song and Parry, 1997a) and product performance (Henard and Szymanski, 2001). Specifically, proficiency in front-end activities is positively associated with new product financial performance (Langerak, Hultink, and Robben, 2004a), while development, testing, and commercialization phase proficiency raises product quality and profitability, assuming competent marketing skills and adequate marketing resources (Song and Parry, 1997a). Furthermore, proficiency mediates the relationship between cross-functional integration and product quality (Song and Parry, 1997b). While this research did not examine proficiency, the essential relationship between cross-functional integration and product quality is captured. At the same time, not examining proficiency is a limitation of this research. Future research should examine the impact of task proficiency with cross-functional integration, resource investments by phase, speed to market, and product quality to improve understanding of their joint effect on profit.

In terms of the data and method, this study has several limitations that can be addressed in future research. The first limitation is the non-random sampling of firms. Also, the projects in the data come from very large conglomerates. The results of this study should be cautiously applied to medium- and small-sized firms, and future research might address the mediating role of speed to market and product quality on new product performance in randomly sampled small-size firms. Second, our data are cross-sectional in nature and future research is required to understand the "over time" implications of the existing model. Finally, as Song and Montoya-Weiss (2001) suggest, it is important for further research to explore a more complex, multilayered analysis of NPD performance. Developing a multi-level model, i.e., industry-firm-project or firm-project-product, would contribute to the literature in terms of explaining the moderating effects of higher-level variables on product performance.

Conclusion

While Henard and Szymanski's (2001) meta-analysis results suggest that process characteristics are not as influential in new product success as are product, strategy, and market characteristics, processes are necessary to implement strategy and deliver product advantage in real-world environments (Noble and Mokwa, 1999). This research demonstrates that process matters in delivering product profitability because it positively impacts profits directly as well as indirectly through speed to market and product quality. Moreover, not only should research account for time-quality-expense trade-offs when examining NPD success, but also development investment timing involves trade-offs with important profit implications.

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