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Is Integration Enough for Fast Product Development? An Empirical Investigation of the Contextual Effects of Product Vision*

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Research into development time performance has suggested that integration—both internal, adopting cross-functional organizational structures for development, and external, involving customers and suppliers in the process—can be a powerful driver when it comes to compressing cycle times and enhancing development punctuality. Some recent studies have also highlighted the compelling role of product vision to obtain high performances with product development. What these studies seem to suggest is that product vision guarantees the right goals and clarity of direction that integration mechanisms need to quickly develop new products and to stay on the development schedule. However, past studies have rarely considered or measured product vision as a construct and explicitly tested whether or not product vision acts as a contingent factor in determining the relationships between the aforementioned organizational drivers and development time. This research study maintains that product vision is crucial to pushing organizational drivers toward increased development efficiency. To find theoretical support for this position and to define a reference framework for the study, previous literature was analyzed. In the framework, both internal and external development integration are assumed to be positively related to time performance; however, these relationships are moderated by product vision. The model was then tested empirically on an international sample of 157 firms to verify and to obtain empirical support for the hypothesized relationships. The results confirm the importance of external integration in achieving better time performance. However, the influence of this driver on cycle time can also be increased by the presence of a very well-defined product vision. The relationship between internal integration and time performance is more complex. Though it seems to slow down the process as a single factor, its interaction effect with product vision is in fact positive. These results have several managerial implications. First, externally integrated development can greatly improve time performance; however, the best results in terms of acceleration can be obtained when there is a well-defined product vision. Furthermore, product vision is essential in the case of internal integration: A cross-functional process alone would not be enough for development acceleration in the absence of product vision. Hence, managers interested in obtaining high time performances should accompany the adoption of integration mechanisms with increased attention to sharing clear objectives and directions with all those—both inside the firm (i.e., team members and functional representatives) and outside the firm (i.e., customers and suppliers)—involved in development and as well as throughout the firm.

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Introduction

New product development is one of the critical processes by which companies sustain or even increase their competitive strength. In fact, it is the means by which members of organizations diversify, adapt, and even reinvent their firms to match evolving markets and technical conditions (Brown and Eisenhardt, 1995).

During the last 15 years companies have invested significant resources into shortening their product development cycle times, that is, the time between idea generation and new product launch (Griffin, 1993). Several research studies have in fact demonstrated that the faster a firm is able to develop new products, the greater the probability it will outperform competitors (e.g., Stalk and Hout, 1990; Vesey, 1992; Wheelwright and Clark, 1992). Every firm, therefore, needs to know what factors determine fast and punctual development. In this way a firm can obtain guidance and set priorities to implement improvement mechanisms for its development process and, ultimately, can support and improve its competitive position in the market.

A large body of previous literature has empirically researched which factors can drive an accelerated new product development process—not only from an exploratory point of view but also more recently from a theory-testing perspective (cf. Griffin, 2002, for a review of these studies). Many of them suggest that an integrated product development process—that is, a process that exploits all available information sources, both internal and external—is necessary to compress the development lead time and to stay on the development schedule.

Some scholars have also pointed out the importance of a clear product vision to achieve superior development performances and the lack of research on this topic. Lynn and Akgun (2001) defined *vision* as a meshing of clarity, support, and stability of development goals and found support for its role in determining a product's market success. Nevertheless, as the same authors stated, empirical evidence on product vision and its role in determining development performance "just scratched the surface of this fruitful and important research area (p. 384)."

As a matter of fact, only some studies investigated product vision effect on development time performance. For instance, Lynn et al. (1999) empirically studied the direct impact of product vision on development time and product success. Kessler and Chakrabarti (1996) highlighted the fact that ambiguous project directions can result in time-consuming activities for a team. Filippini, Salmaso, and Tessarolo (2004) explored the moderation effect exerted on some organizational mechanisms by a clearly defined and clearly communicated development strategy. Bajaj, Kekre, and Srinivasan (2004) found evidence for the contingent effect of project oversight level—which ensures that the team pursues the right objectives—on the relationship between customer involvement and time performance.

What all these studies seem to suggest is that product vision ensures a fog-free environment in terms of clarity of goals and directions in which the organizational mechanisms can help speed up new product development and can respect the development schedule. If a contextual role of product vision were empirically confirmed, some important implications for the implementation of development process improvement mechanisms would stem from it. To compress its cycle time, a firm would not only have to improve the integration of its process, as already suggested by a large body of research, but also would state a clear product vision for the product being developed and would instill that vision in all those involved in the integrated development. Without doing so, integration mechanisms may be useless in achieving a fast and punctual development for new products. Hence, the road to improvement would have to involve a more time-consuming and greater effort than is commonly perceived by firms since the ability to define a clear product vision would have to become a structural element of the process.

However, despite its importance there is little evidence on the relationship between product vision and other organizational constructs, and further research is necessary. The present article aims to fill this gap and to contribute to the knowledge of product vision in the context of new product development by performing the investigation just described and by providing empirical support for the importance of

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product vision in obtaining a fast product development process. In particular, the role of product vision as a moderating factor of the relationships between integration, both at internal and external levels, and time performance is discussed and analyzed. The investigation considered a sample of Japanese and Italian small and medium-size enterprises that operate in a business-to-business (B2B) marketplace producing mechanical machinery, mechanical components, or electronic components to be used by other firms (i.e., the firms are classified standard industrial code [SIC] 35 and 36). In this context, the development cycle time is critical. Indeed, a delay in the development of a supplied component is expected to delay the development of all new products that embody that component (Hartley, Zirger, and Kamath, 1997), with negative consequences on the time performances of all new products that embody the component downstream in the supply chain. Similarly, slow development for machinery can slow down the operations of all downstream firms that need that machinery.

The article is organized as follows. In the first section, the previous literature is analyzed to properly define the drivers and performances of interest and any previous empirical evidence on the relationships between them. In the second section, the sampling criteria is stated, the sample defined, and the sample characteristics analyzed. In the third section, the measures for each concept—drivers and performances identified in the literature review phase—are defined, and a descriptive analysis of these measures is provided. In the fourth section, empirical data are analyzed using regression models to test for the hypothesized relationships and moderation effects. In the last section, the results and managerial implications are discussed.

Background and Hypotheses

Time Performance

The ability to reduce cycle time in new product development is increasingly viewed as the key to innovation success and profitability (Cooper and Kleinschmidt, 1994). Quick development extends a product's sale life, creates opportunities to charge a premium price, and makes development and manufacturing cost advantage possible (Karagozoglu and Brown, 1993). Indeed, developing products quickly is usually more productive and less costly because lengthy times in product development tend to waste resources on peripheral activities, changes, and mistakes (Eisenhardt and Tabrizi, 1995).

Staying on the development schedule is another important factor in helping gain market success, especially in a B2B context. Previous research has given various names to this dimension such as *on-time performance* (Cooper, 1995; Lambert and Slater, 1999; Swink, 2003), *staying on schedule* (Cooper and Kleinschmidt, 1994, 1995), *launched on time* (Griffin and Page, 1996), and *launched against an accelerated schedule* (Filippini, Salmaso, and Tessarolo, 2004). In several empirical studies, this dimension of time performance has been found to be correlated to development acceleration (Cooper and Kleinschmidt, 1994, 1995; Filippini, Salmaso, and Tessarolo, 2004; Karagozoglu and Brown, 1993). This is not surprising since it is reasonable that the greater the firm's ability to accelerate the process, the greater the probability it will also stay on schedule with the development.

Hence, in the context of the present study, the *time performance* construct is defined as a firm's ability to reduce the time needed to develop new products as compared to the time previously needed to develop past products with similar levels of innovativeness and complexity and to respect the development schedule.

Development Integration

Previous literature has often seen the new product development process as a problem-solving activity by which intangible ideas are transformed into tangible new products (see Brown and Eisenhardt, 1995, for an extensive review of this literature). This transformation is made by reducing the gap between available and necessary information or, in other words, by progressively reducing uncertainty throughout problem-solving cycles (Clark and Fujimoto, 1991; Iansiti and Clark, 1994; Wheelwright and Clark, 1992). For the process to succeed, besides simply acquiring new information it is crucial to both collect the information already disseminated in a firm's departments and to disseminate new information across them for the development of future products (Adams, Day, and Dougherty, 1998). An integrated development process usually favors both the acquisition of new information and its dissemination to quickly develop new products.

Development integration refers to the cooperation and communication between internal and external product development groups (Millson and Wilemon, 2002). A common result of previous research is, simply stated, that the lower a process's level of integration (i.e., the lower the quality and quantity of information shared during product development), the slower the development process (Kessler and Chakrabarti, 1996). As the previous definition suggests, integration can be achieved internally or externally. Internal integration is mainly related to a firm's ability to put together and exploit all information sources available inside the firm (Song, Montoya-Weiss, and Schmidt, 1997) and to reduce the differences between the thought worlds typical of each functional area (Dougherty, 1992). External integration, on the other hand, is related to the ability to gain further information by involving external entities in the development process through network relationships. These entities are usually suppliers (e.g., Hartley et al., 1997; Petersen, Handfield, and Ragatz, 2003) and customers (e.g., Campbell and Cooper, 1999; Griffin and Hauser, 1993).

Several studies have thoroughly investigated internal integration mechanisms—such as the use of cross-functional teams for the development activities, integration between the design department and marketing, and collaboration between design and manufacturing—and have demonstrated the positive role of internal integration to achieve better time performance (Brown and Eisenhardt, 1995; Clark and Fujimoto, 1991; Cooper and Kleinschmidt, 1994; Dyer, Gupta, and Wilemon, 1999a; Eisenhardt and Tabrizi, 1995; Gupta and Wilemon, 1990). Proximity and continuous communication between team members are mainstays of concurrent development, making it possible to overlap and compress the development phases, speeding up the process (Clark and Fujimoto, 1991; Cordero, 1991; Imai, Nonaka, and Takeuchi, 1985; Mabert, Muth, and Schmenner, 1992). Furthermore, mutual comprehension of the design requirements from each functional area makes it possible to coordinate the overlapped phases, thus avoiding delays (Swink, 2003). As a matter of fact, the increase in available information helps team members to anticipate downstream development problems while they are still limited, making it easier quickly solve and correct them (Eisenhardt and Tabrizi, 1995; Zirger and Hartley, 1996), and stimulates team creativity, improves understanding of the project, and helps arrive at original solutions to quickly fix the problems that may arise during development (Griffin, 1997).

Hence, in the context of the present study, *internal integration* construct refers to the extent to which a firm uses cross-functional teams (i.e., groups of at least two people coming from different functional areas, according to Brown and Eisenhardt, 1995) to manage the development of new products. Based on the definition and the aforementioned literature, it then makes sense to state the following hypothesis:

H1: Greater internal integration is associated with better time performance.

To increase the information available at the beginning of the development process and **to** reduce market and technological uncertainties, a firm can also increase the external integration of its process by collecting the information needed to achieve substantial reductions in uncertainty during development from well-informed external entities. External integration is then commonly intended as a firm's ability to involve suppliers and customers—the two most crucial external entities for performing product development quickly and punctually—in the development activities (cf., e.g., Dröge, Jayaram, and Vickery, 2004).

Supplier involvement tends to reduce the team workload since the carrying out of certain steps is delegated to those who have the competences and information to perform them more quickly (Kessler and Chakrabarti, 1996; Zirger and Hartley, 1996). As supplier involvement reduces the project span for a firm's development team, these steps can be effectively overlapped with internal development activities, thus shortening the critical path and further speeding up the process (Clark, 1989). At the same time, external integration of the process by means of supplier involvement permits team members to focus on the subset of development tasks in which they can take advantage of their key competences, skills, and information. Supplier involvement also improves the way the team thinks about product design, integrating suppliers' ideas and different perspectives into the product during several stages of the process. This means that future development problems are more likely to be caught early on, when they are easier to fix (Dröge, Jayaram, and Vickery, 2000; Eisenhardt and Tabrizi, 1995).

Besides supplier involvement, the initial phase of a firm's development process relies more and more on customer involvement, which can be viewed as the downstream counterpart of supplier involvement (Dröge, Jayaram, and Vickery, 2004). The benefits of customer involvement are indeed very similar to those deriving from supplier involvement. Therefore, several authors have stressed the importance of mutual collaboration between customers and suppliers, especially in B2B contexts (Campbell and Cooper, 1999; Hartley, Zirger, and Kamath, 1997; Ragatz, Handfield, and Petersen, 2002). Constant communication with the customer leads to less design rework, and ultimately to better time performance in the design phase (Bajaj, Kekre, and Srinivasan, 2004). Ensuring that the customer is involved very early on in the process, even at the idea development stage, is among the factors making it possible to develop new products on time and in time (Cooper, 1995). As one of the reasons for the delay of product development, Dyer, Gupta, and Wilemon (1999b) identified difficulties in product and market definition, which can be greatly reduced by involving customers, as well as suppliers, early on in the development process. Gupta and Souder (1998) discovered that short-cycle-time companies, when compared to long-cycle-time companies, were characterized by extensive user involvement at the very early stages of new product development.

In the context of the present study, the *external integration* construct is the active involvement of both suppliers and customers early on in the development process. *Active involvement* means, in the context of the present study, the formal participation of suppliers and customers in predevelopment activities (i.e., specification definition, project planning, preliminary design) in a traditional face-to-face way or by means of innovative forms of e-connection to exchange product-related information (e.g., specs draft, computer-aided design [CAD] drawings, renderings).

It is important to point out that in this research study no distinction was made between supplier involvement and customer involvement at the construct definition level. External integration is a strategic approach of the firm aimed at key boundary-spanning initiatives for fostering high-level coordination between a firm and its suppliers and customers to effectively support product design and development activities (Dröge, Jayaram, and Vickery, 2004). Therefore, the degree of external integration of the process is indicated by the involvement degree of both suppliers and customers in the development activities. This is especially true in the context of the present study, which is focused on firms that manufacture mechanical and electronic components to be incorporated into other products or machinery to be used by industrial customers. These firms operate in a B2B context. Therefore, each firm, its suppliers, and its customers usually share a mainly cognitive and technical approach to the product—as opposed to the mainly perceptive perspective of the customer in a business-to-consumer context. Furthermore, each supply chain actor is technically qualified since it has its own development processes and can easily share what it knows and wants with the other entities (i.e., customers and suppliers) involved in the process. In other words, the type of information exchanged, which usually entails the exchange of CAD drawings or well-defined product metrics (e.g., technical specifications for the product or process, performance requirements), is easily understood by all three players, and the media used for the exchange (e.g., e-mail, network-enabled electronic data interchange (EDI) systems, face-to-face meetings) is familiar to all three players. In conclusion, from an information point of view, contributions to the development process from suppliers and customers are, in the context of this study, quite similar. Based on the literature and the previous definition, the following hypothesis is proposed:

H2: Greater external integration is associated with better time performance.

Product Vision

It is worth noting that increased information content, such as that deriving from increased integration, also implies greater complexity of information management activities and coordination tasks (Zirger and Hartley, 1996). When this occurs, it has been empirically found that the development team, which may include customer and supplier representatives, might skip a priori the analysis of some alternative solutions or not analyze in depth each possible solution because the team is overloaded with information (Keller and Staelin, 1987). Inadequate information processing during the development process may in turn have negative effects on the efficiency of the process, such as schedule delays (Clark and Fujimoto, 1991). In addition, many recent studies have found that increasing the information available to a team can decrease the usability of such information (Fisher, Maltz, and Jaworski, 1997; Kahn, 1996; Moenaert and Souder, 1996).

To reach the level of coordination necessary to process information effectively and efficiently and to align functional perspectives with development goals, it is necessary for all those involved to share a strong vision regarding new products. Product vision has been defined as the fit between an organization's strategy and the market needs to create an effective product concept (Brown and Eisenhardt, 1995) or as the clarity of directions, goals and objectives for the development of a product within a team (Crawford and Di Benedetto, 2003). Lynn and Akgun (2001) defined vision in the product development process as the meshing of clarity (i.e., existence of very specific goals that provide the team with directions), support (i.e., sharing and support of goals and objectives within the team), and stability (i.e., consistency of objectives over time). In the context of the present study, all these contributions were considered, and the *product vision* construct is defined as a firm's ability to define clear objectives and a well-recognized strategy for the development process and to share these objectives and strategy with all those involved in the development.

Lynn, Skov, and Abel (1999) found empirical support for the notion that product vision creates a psychologically safe environment for the team to work in since it clearly signals to members what the development goals are. Lynn and Akgun (2001), in the case-based part of their study, compared and contrasted successful and unsuccessful new products and discovered that most of the unsuccessful ones lacked a clear vision for the developed product. However, when it comes to empirical evidence on the contextual influence of product vision on the internal integration–time performance relationship, there is very little research, and what does exist is partially contradictory. Song, Montoya-Weiss, and Schmidt (1997) empirically discovered that a team works more efficiently when its members share a common perception of objectives and strategy and of the need to collaborate. Kessler and Chakrabarti (1996) argued that ambiguous project concepts allow for greater speculation and conflict about what is to be produced, which can result in time-consuming readjustments and debates. Dyer, Gupta, and Wilemon (1999a, 1999b) found that factors that greatly delay product development include the difficulty to clearly define product and market objectives. However, Lynn et al. (1999) discovered no significant relationships between level of product vision and speed of development. Similarly, Kessler and Chakrabarti (1999) found limited empirical support to the notion that clearness of goals is a direct antecedent of a fast development pace.

All these findings obviously do not exclude the possibility that product vision may act as a moderator of other relationships. It seems reasonable, for instance, that internal integration mechanisms work better when, within the firm, there is a clear definition of specific goals and objectives for new products, clear communication of these goals and objectives, and a good and shared strategy to guide the development process. Even if a firm adopts cross-functional internal organization to develop new products, the product vision may be unstated or unclear. As Song, Xie, and Di Benedetto (2001) maintained, merely imposing a cross-functional structure for product development does not ensure that functional representatives will work together effectively. The necessary condition for this to happen is the development of clear and common goals (Kahn and Mcdonough, 1997; Song, Xie, and Di Benedetto, 2001). This point is confirmed by several other studies on cross-functional integration (e.g., Griffin and Hauser, 1996; Parry and Song, 1993; Pinto, Pinto, and Prescott, 1993). Therefore, what is expected is that the impact of internal integration on time performance is greater when the team embodies a clear, shared product vision. Consequently, it seems reasonable to state the following hypothesis:

H3: The effect of internal integration on time performance depends on product vision. With a fixed internal integration level, its effect on time performance is greater when the level of product vision is higher.

With regard to external integration, Filippini, Salmaso, and Tessarolo (2004) analyzed the interactions between the impact of several new product development drivers and interactions on time performance. Among their results, the authors found that the impact of customer involvement and supplier involvement in the development process entirely depends on the firm's ability to clearly define new product objectives, to clearly state a good strategy as a guide for development activities, to clearly communicate to the team the role products to be developed play in influencing company objectives, and to ensure agreement among team members on the objectives and strategy defined. Similarly, Petersen, Handfield, and Ragatz (2003) found that what can make the difference between a successful and an unsuccessful project—where *success* has been defined as excellence in cost, quality, and cycle time—in the case of early supplier involvement is the sharing and

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understanding of the project objectives by all the parties involved in the development (i.e., both the team and suppliers). Bajaj, Kekre, and Srinivasan (2004) empirically found that, despite the large body of literature advocating increasing customer involvement in the development process to shorten development times (e.g., Cooper, 1995; Gupta and Souder, 1998), the direct (i.e., by itself) effect of customer involvement during the design stage was negatively associated with time performance. Nonetheless, the authors discovered that customer involvement might have a positive interaction effect with the level of supervision on the part of the project manager and may influence time performance. The interaction effect was found to be greater than the direct effect: The managerial implication is that customer involvement is effective when the project manager sets a clear direction for the project by overseeing it.

The involvement of external organizations and people during development (i.e., suppliers and customers) entails the management of complex relationships and information exchanges. This type of involvement may therefore lead to misunderstandings and delays if the definition of the goals is not clear and shared. However, it is a powerful driver when there is a clear, shared product vision. Since there is little specific investigation of the effect of product vision on the relationship between external integration and time performance, to fill this gap following hypothesis requiring empirical verification is stated.

H4: The effect of external integration on time performance depends on product vision. With a fixed external integration level, its effect on time performance is greater when the level of product vision is higher.

Figure 1 summarizes all the relevant constructs for the present research study as well as the hypothesized relationships among them and represents the reference framework for the study.

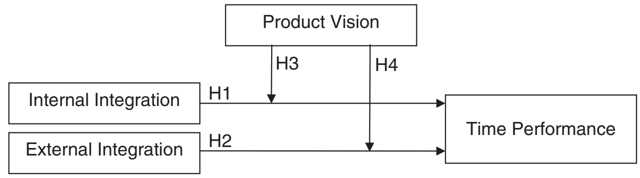

Figure 1. Reference Framework

Data Collection and Methodology

To test the four hypotheses, data were gathered from a sample of Japanese and Italian manufacturing firms producing industrial goods in B2B contexts.

Business literature contains many examples of large firms that have successfully reduced cycle time, whereas not much work has been done to find out how small and medium firms are managing to improve their time performances (Ali, Krapfel, and LaBahn, 1995). There is, then, a need for more research focused on these firms since it has been claimed that they produce the greatest number of new products per million dollars invested in research and development, represent a large and crucial section of the manufacturing network of several industries, and play a crucial role in the global economy and, in particular, the economies of Japan (cf., e.g., Kawai and Urata, 2002) and Italy (cf., e.g., Nassimbeni, 2003). Therefore, to focus the study only on small and medium-size enterprises and to reduce the number of variables to control, the following constraints were imposed a priori on the size of firms during the reference population identification stage: (1) revenues ranged from \$15,000,000 to \$150,000,000; and (2) number of employees ranged from 100 to 1,000. The reference population—that is, those satisfying these constraints—was identified using the B2B databases of the Japan Management Association and Dun & Bradstreet, respectively, for Japan and Italy.

Empirical investigations on product development are usually performed at a project or program level (Montoya-Weiss and Calantone, 1994). Cooper and Kleinschmidt (1995, p. 376) pointed out the differences in terms of result scope between project- and program-level studies. They stressed the fact that although studies with a project level of analysis are fundamental to increasing knowledge on new product development processes, "there may be company practices that are not apparent at the project level and yet are important . . . These practices may be missed—simply not observed or measured—when the unit of analysis is the project." The authors maintain that to study the effects of some particular practices—such as a clear and solid strategy for product innovation or the use of a product innovation chart as a method for firms to state a clear and well-defined product vision (Crawford and Di Benedetto, 2003)—a program level may be more effective than a project level of analysis. The present study, therefore, adopted a program-level unit of analysis, which on the basis of the aforementioned considerations seemed to be best suited to achieving the goals of this particular study. In fact, in accordance with the objectives of this study, the program level can provide firms with useful evidence about the long-term effects on time performance of specific integration improvement actions that may involve product vision and may be related to all of the projects carried out by a firm in its development program rather than to a specific project. The *development program* was defined as the set of new products developed and launched by a firm in the three years previous to the study.

All the firms identified in the databases were included in the reference population if their development program had developed at least five new products, thus avoiding inconsistent responses on a one- to five-point scale. Since it was impossible to determine whether or not each firm extracted from the databases actually satisfied the constraints set forth here, a two-stage sampling approach was adopted. First, 1,000 Italian and 1,000 Japanese firms were randomly selected from databases and were contacted by phone or fax to verify whether they were suitable and willing to participate in the study. This approach made it possible to identify a subsample of 182 Japanese and 201 Italian firms, each one of which was sent a paper-and-pencil questionnaire. The questionnaire was mailed to the senior executive of the new product development department and was accompanied by a letter detailing the purpose of the study, the structure of the questionnaire, and the unit of analysis. Phone assistance was provided to ensure that the information gathered was both complete and correct.

The returned number of usable questionnaires was 154: 79 from Japanese and 75 from Italian firms, corresponding to a response rate of 43.4% and 37.3%, respectively. The mean number of employees in the sample was 250 (standard deviation [SD] 171; range, 100–937). Mean sales were $37.5 million (SD 17.5; range, 11–132).

Measures

All constructs were measured using multiple-item perceptual scales. Each item was provided with a closed-end answer on a one- to five-point scale referring to the percentage of projects in the three-year program that satisfied the question (1 = less than 20%; 2 = between 20% and 40%; 3 = between 40% and 60%; 4 = between 60% and 80%; 5 = more than 80% of projects in the program).

Time performance (TP). This construct was measured using a two-item scale. The items asked what percentage of projects belonging to the program was launched on time (ON_TIME) and what percentage was developed faster than similar past projects, that is, with similar levels of complexity and newness (TTM_RED).

Internal integration (II). This construct was measured using a three-item scale. The items asked what percentage of projects belonging to the program formally adopted a multifunctional team—with representatives from at least the design, manufacturing, and marketing departments—to manage the development (TEAM), whether there was extensive communication and consultation between the design and manufacturing departments (INT_DMF), and whether there was extensive communication and consultation between the design and marketing department (INT_DMK).

External integration (EI). This construct was measured using a four-item scale. The items asked what percentage of projects belonging to the program formally involved their main customers during development to align technical specifications with customer needs (CUST_IN), whether some form of e-connection with customers was used during the design stage to facilitate communication and cooperation with customers (CUST_COM), whether main suppliers were formally involved from the beginning of development to align the technical specifications of the supplied components with the firm's needs (SUP_INV), and whether there was some form of e-connection with the suppliers involved in the design stage to facilitate communication and cooperation during development (SUP_COM).

Product vision (PV). This construct was measured using a three-item scale. The items asked what percentage of projects had clear and formal definitions of the development objectives—including, but not limited to, revenues, profits, market share, customer satisfaction—(VIS_CLAR), whether these objectives were clearly communicated to all the functions involved in the development (VIS_COM), and whether there was agreement and sharing of objectives among all the functions involved in the development (VIS_SHAR).

Before answering the questions, each respondent was asked to list all new products belonging to the program. In this way the percentage estimation for each answer was easy and straightforward. Each construct was then measured averaging the items on its

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Table 1. Basic Statistics, Reliability, and Correlation Analysis

	Construct	Mean	Standard Deviation	Cronbach's Alpha	Correlation Coefficients (p-Value) 2	3	4
1	Time Performance	2.84	.858	.46[a]	.096 (.224)	.163* (.041)	.246** (.002)
2	Internal Integration	3.51	.743	.65		.346** (.000)	.418** (.000)
3	External Integration	2.63	.844	.67			.438** (.000)
4	Product Vision	3.66	.939	.76			—

[a] For this two-item scale, interitem correlation, instead of Cronbach's alpha, has been reported.
* Correlation is significant at the .05 level (2-tailed).
** Correlation is significant at the .01 level (2-tailed).

scale. Table 1 reports the correlations between construct measures and Cronbach's alpha coefficient to verify each one's reliability. Interitem correlation for the two-item time performance scale was .46. The construct reliability ranged from .63 to .76, below what is commonly desirable for a theory-testing study. This makes the model testing rather conservative.

An exploratory factor analysis was preliminarily performed to verify if the empirical factorial structure agreed with the hypothesized one and whether or not the measure exhibited unidimensionality. The factor analysis, like all the other statistical analyses, was performed using SAS System v.8. A nonorthogonal PROMAX rotation was adopted, the most appropriate when a degree of correlation among constructs is expected (Hatcher, 1994). The result, shown in Table 2, indicates a good degree of unidimensionality for each construct. A further item, involving top-management overseeing and support for the development process, was used to measure product vision. However, the factor analysis revealed that this item loaded on more than one construct, so it was deleted to purify the measure (Churchill, 1979). The factor analysis was also separately performed on each national sample. This revealed that the factorial structure was the same for the Japanese, Italian, and pooled samples. Table 2 reports only factor loadings greater than .300 to make result interpretation easier.

Table 2. Factor Analysis (PROMAX Rotation)[a]

Item	Time Performance	Internal Integration	External Integration	Product Vision
ON_TIME	.776			.316
TTM_RED	.863			
TEAM		.656		
INT_DMK		.690		
INT_DMF		.704		
CUST_INV			.665	
SUP_INV		.321	.642	
CUST_CON			.711	
SUP_CON			.824	
VIS_CLAR				.802
VIS_SHAR				.827
VIS_COM				.814

[a] Factor loadings less than .300 are not shown.

The factor analysis shows that all external integration items load on a single construct regardless of whether they refer to customer-side or supplier-side integration. This result provides some evidence of construct validity to our context and content-based decision about the consolidation of integration with both customers and suppliers into a single construct called external integration.

Analysis

The reference model was initially tested without considering interaction effects; then a second test was performed to take these effects into account and to statistically verify the whole model.

The following equations express the tested hypotheses.

$$\text{Model 1}: \text{TP} = \alpha_0 + \alpha_1 \cdot II + \alpha_2 \cdot EI + \varepsilon_1$$

$$\text{Model 2}: \text{TP} = \beta_0 + \beta_1 \cdot II + \beta_2 \cdot EI + \beta_3 \cdot II \cdot PY + \beta_4 EI \cdot PV + \varepsilon_2$$

where II stands for internal integration level, EI is external integration level, and PV is product vision level.

A third model was then tested to verify whether the time performance level is dependent on the country from which data are drawn. To this end, a dummy variable, NAT, was introduced into the model. This variable had a value of 0 when the observation was

Table 3. Reference Models: Parameter Estimates

Independent Variables	Standardized Regression Coefficients			
	Model 1	Model 2	Model 3	Model 4
Integration Level				
Internal Integration (II)	.218*	− .185*	− .197*	− .203*
External Integration (EI)	.310*	.235*	.218*	.242*
Moderated Effects				
Product Vision · Internal Integration (II · PV)		.511**	.516**	.497**
Product Vision · External Integration (EI · PV)		.209*	.210*	.220*
Control Variables				
Nationality (NAT)			− .043	− .022
Nationality · Internal Integration (NAT · II)				.019
Nationality · External Integration (NAT · EI)				.080
Nationality · Product Vision · Internal Integration (NAT · PV · II)				− .136
Nationality · Product Vision · External Integration (NAT · EI · PV)				− .157
Model p-Value	.038*	.020*	.031*	.048*
Adjusted R^2	.127	.246	.249	.253

* Significant at the .05 level.
** Significant at the .01 level.

drawn from a Japanese firm and 1 when the firm was Italian. The resulting model is then

$$\text{Model 3}: \quad TP = \gamma_0 + \gamma_1 \cdot II + \gamma_2 \cdot EI + \gamma_3 \cdot II \cdot PV + \gamma_4 \cdot EI \cdot PV + \gamma_5 \cdot NAT + \varepsilon_3.$$

Finally, a fourth model was used to test whether the relationship path differs between Japanese and Italian firms (model 4).

$$\text{Model 4}: \quad TP = \delta_0 + \delta_1 \cdot II + \delta_2 \cdot EI + \delta_3 \cdot II \cdot PV + \delta_4 \cdot EI \cdot PV + \delta_5 \cdot NAT + \delta_6 \cdot II \cdot NAT + \delta_7 \cdot EI \cdot NAT + \delta_8 \cdot II \cdot PV \cdot NAT + \delta_9 \cdot EI \cdot PV \cdot NAT + \varepsilon_4.$$

To reduce the risk of multicollinearity, all independent variables were mean centered before testing the models (Jaccard, Turrisi, and Wan, 1990). Most of the results reported in Table 3 agree with the proposed hypotheses.

Model 1 highlights the positive link between integration mechanisms—internal and external—and time performance, as proposed by H1 and H2. Model 2, which also investigates the product vision's moderation effect on each relationship, clearly shows the path of influence between integration mechanisms and time performance. The main results are summarized following.

A high level of external integration exerts a positive effect on time performance. This effect is partially independent of the level of product vision. However, the presence of a significant moderation effect suggests that product vision acts by enforcing this positive influence on time performance. Internal integration has a more complex relationship with time performance. The direct effect, independent of product vision, is significant and negative, whereas the moderated effect—that is, dependent on the level of product vision—is significant and positive.

To better understand the nature of this result, the approach suggested by Ali (2000) was used. Since the value of the standardized regression coefficient β_3 indicates how the relationship between internal integration and time performance varies across different levels of product vision, a low score for product vision can be set as one standard deviation below its mean level, and a high score is set as one standard deviation above its mean level. As the variables were mean centered and the coefficients in Table 4 are standardized, a low product vision score corresponds to -1, a high product vision score corresponds to $+1$, and an average product vision score corresponds to 0. Using the model 2 equation and the corresponding coefficient estimates from Table 4, it is possible to calculate the effect of internal integration on time performance when product vision is,

Table 4. Internal Integration Effect for Different Product Vision Levels

Product Vision Level	Slope Computation	Slope of the Resulting Effect
Low (− 1)	$\beta_1 + \beta_3 \cdot PV = \beta_1 - \beta_3 = -.185 - .511$	− .693
Average (0)	$\beta_1 + \beta_3 \cdot PV = \beta_1 = -.185$	− .185
High (+ 1)	$\beta_1 + \beta_3 \cdot PV = \beta_1 - \beta_3 = -.185 + .511$	.326

respectively, low, average, and high. The calculation is reported in Table 4.

In the first case, when product vision is low, an increase in internal integration greatly decreases time performance. In the second case, when product vision is high, an increase in internal integration causes an increase in time performance. If the product vision has a mean value, the slope is slightly negative, so an increase in internal integration slightly decreases time performance.

No major differences seem to emerge between the two countries, as highlighted by the results of the analysis for models 3 and 4. These models also confirm the conclusions suggested by model 2.

Discussion and Implications

This study's empirical results shed new light on how process integration relates to time performance and on the contextual role played by product vision.

Regarding external integration, the empirical data show that the involvement of suppliers and customers in development can help in decreasing the cycle time and in staying on the development schedule. Nevertheless, involving suppliers early on can dramatically reduce the project span as well as the internal team workload, thus speeding up development. The reduced span also makes it possible to increase the level of parallel development since the external and internal activities can be efficiently and effectively overlapped. Furthermore, the greater technical competences of suppliers regarding the components or modules they develop make it easier to identify development problems early on and to fix them quickly. Similarly, involving customers from the beginning can help clarify what products should be developed. This can cut the need for reworks caused by requirement misunderstandings and increases the possibilities for parallel development since customer requirements can be quickly translated into technical requirements using well-recognized techniques (e.g., by using quality function deployment; see Griffin and Hauser, 1993).

These conclusions are in line with the considerable literature advocating that supplier and customer involvement speeds up development (e.g., Clark, 1989; Cooper, 1995; Cooper and Kleinschmidt, 1994; Cordero, 1991; Dröge, Jayaram, and Vickery, 2004; Hartley et al., 1997; Hartley, Zirger, and Kamath, 1997; Mabert, Muth, and Schmenner, 1992; Petersen, Handfield, and Ragatz, 2003; Ragatz, Handfield, and Petersen, 2002). Nevertheless, the empirical results demonstrate that external integration increases development speed and punctuality more when there is high product vision. In the early stages, the existence of clear and shared goals within the team makes it possible to ask customers the right questions and to involve suppliers in defining the right directions for the product and its features. This can reduce the coordination workload and can increase the pace of communication and collection of information from external entities.

The relationship between internal integration and time performance emerging from the data analysis is slightly more complex. The impact of this driver on performance does in fact heavily depend on the level of product vision inside the firm. If the level of vision is high, greater internal integration may enhance time performance; if it is low, increasing internal integration might eventually lengthen development time and reduce punctuality.

Some important managerial implications stem from this result. In fact, the mere adoption of a cross-functional team for development does not automatically guarantee acceleration in development, and speed improvement actions in this direction should be adopted carefully. Indeed, the empirical evidence seems to suggest that an essential ingredient of efficient cross-functional development is clarity of process objectives among team members. When such clarity is lacking, coordination among members and functions can become as overwhelming as the need for reworks since directions are neither set nor clear. This haze on the road to development can greatly slow down the process. Hence, in such situations the use of a cross-functional approach would not be sufficient to collect and organize all the information needed to efficiently develop new products, and the provision of additional managerial support for the development team would be advisable. For instance, to collect information on technology or the market, the team may be helped by the adoption of other mechanisms such as technical problem solving, experimentation, market research, and testing (Griffin and Hauser, 1996), which may favor coordination among team members and the definition of a shared vision. Furthermore, the increased supervision of development activities by top management or the project manager may contribute to achieving similar results (e.g., Bajaj, Kekre, and Srinivasan, 2004; Brown and Eisenhardt, 1995). In conclusion, when adopting a cross-functional approach to develop new products, managers should also take care to develop and spread a clear product vision by clearly explaining what the development objectives and directions are to all those involved, as well as the role of the new products in sustaining the firm's competitive position. This is an essential way to speed up the process to its maximum level, taking advantage of development integration.

Finally, it is also interesting to note that the results do not depend on firm nationality, despite the well-known cultural and industrial differences between Japan and Italy (cf. Hofstede, 1990). The observed statistical invariance of the analyzed relationships between the two national subsamples leads to hypothesize that these results may have a general validity well beyond the firms of the considered nations, at least for small and medium-size firms operating in the industries considered, namely, SIC 35 and SIC 36.

Limitations and Further Research

Some limitations to this study suggest directions for future research. First, this study focused on small and medium-size enterprises, which represent a large section of the manufacturing network in many industries and contribute greatly to the global economy. For this reason, research on how to improve their operations is particularly important. Furthermore, focusing on small and medium-size firms gives also an advantage in terms of result reliability: The number of variables that need to be controlled is reduced by adopting a contingent approach. However, what would the results of the framework test be if it was performed on a sample of bigger firms? There is no theoretically sensible reason to hypothesize that there might be differences between big and small or medium-size enterprises. Nevertheless, this has not been tested yet; hence, the conclusions discussed here can not be extended to larger organizations without further research. Second, this study considered firms from only two manufacturing industries. Once again, then, further research is necessary to gain a more general understanding.

Third, as far as the relationships are concerned, no major differences between the Japanese and Italian samples are observed. As stated already, this may lead to hypothesize a global validity of these relationships. However, to test and eventually confirm this hypothesis, further research on firms in countries other than Japan and Italy is necessary. Fourth, the results presented here study the contextual effect of product vision on the relationship between each integration-related driver and time performance. Although the variances of the dependent variable explained by this study's models are quite satisfactory, previous research suggests large lists of variously classified drivers that influence time performance. Further research is also necessary to determine whether or not the same contextual effect that moderates the influence of integration-related drivers also moderates the relationships between other drivers and time performance.

Finally, an increasing body of literature stresses the importance of product vision in determining development performances. Although the implications for firms that emerge from this article are quite clear and suggest acting to improve product vision, the specific actions required to enhance it are still unclear. How do firms act to increase their product vision? What are the drivers of a strong product vision? These questions remain unanswered and represent a possible focus of future research.

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