INFORMATION TECHNOLOGY AND THE AMBIDEXTERITY HYPOTHESES: AN ANALYSIS IN PRODUCT DEVELOPMENT

IE Working Paper DO8-134-I 22-03-2007

Isabel Mª Prieto
Universidad de Valladolid
Phone: + 34 983 42 39 51
Fax: + 34 983 42 38 99
isabo@eco.uva.edu

Elena Revilla
IE Business School
Phone: + 34 91 568 96 00
Fax: + 34 91 561 09 30
elena.revilla@ie.edu

Beatriz Rodriguez
Universidad de Valladolid
Phone: + 34 983 42 30 00
Fax: + 34 983 42 38 99
brodriguez@eco.uva.edu

Abstract

We investigated ambidexterity, defined as the capacity to simultaneously achieve exploration and exploitation activities at a product development level. Building on the knowledge management literature, we argue that in formation technology –defined by a combination of the convergent and dive rgent dimension- facilitate ambidexterity. Further, ambidexterity mediates the relationship between IT and performance. We found strong evidence that ambidexterity mediates the relationship between the IT that encourage these activities and subsequent performance in product development. Data collected from 80 product dev elopments supported our hypotheses.

Keywords

Product Development, Information Technology, Performance Knowledge Management, Ambidexterity

INTRODUCTION

The conceptual distinction between exploration and exploitation activities has been intensively studied in various disciplines (Adler et al, 1999; He and Wong, 2004) and is a common theme in the management literature (March, 19991; Levinthal and March, 1993). Exploration is a manifestation of organizational learning that entails activities such as search, variation, experimentation, challenging existing ideas, and research and development. It is thus about improving and renewing the organization's expertise and competences to compete in changing markets by introducing the variations needed to provide a sufficient amount of choice to solve problems (March, 1991). Exploitation is a different manifestation of organizational learning that involves efficiency, selection, implementation, control, refining and extending existing skills and capabilities. It reflects how the firm harvests and incorporates existing expertise and competences into its operations, not just for economizing the efficiency of existing resource combinations (Levinthal and March, 1993), but also for creating new ones.

Some studies (Ghemawat and Costa, 1993; Bierley and Chakrabarty, 1996) suggest that exploration and exploitation are competing activities, which results in the need for organizations to emphasize one at the expense of the other. In contrast, most studies (Tushman and O'Reilly, 1996; Eisenhardt and Martin, 2000; Katila and Ahuja, 2002; He and Wong, 2004; Auh and Menguc, 2005) propose that exploration and exploitation are complementary activities, so companies should strike the correct balance between them. This balanced view is embedded in the concept of organizational ambidexterity (He and Wog, 2004). Organizational ambidexterity is the ability to pursue exploitative and explorative activities simultaneously (Jansen et al., 2005). In other words, ambidextrous firms are able to be aligned and efficient while also adaptive enough to environmental changes (Gibson and Birkinshaw, 2004). Previous studies argue that most successful firms are able to reconcile both exploration and exploitation by being ambidextrous, and in so doing enhance their long-term competitiveness (Gibson and Birkinshaw, 2004; He and Wong, 2004; Tushman and O'Reilly, 1996).

Latest research is now focused on how firms can achieve ambidexterity. In example, Gibson and Birkinshaw (2004) introduce the notion of contextual organizational ambidexterity to analyse the role of the behavioural context (human side of organizations) in achieving the balance between alignment and adaptability at a business-unit level. Originally, Tushman and O´Reilly (1996) analyse structural ambidexterity by recognizing the role of the processes and systems (separate structures) present in organizations to achieve the desired balance between exploration and exploitation. Likewise, the integration of exploration and exploitation is central to work studying dynamic capabilities (Eisenhardt and Martin, 2000; Zollo and Winter, 2002) and their attempts to analyse how firms develop dynamic capabilities. In the development of new products firms also need to fit between exploiting existing product innovation competences and exploring new ones, so product development literature has tried to analyse the way that organizational characteristics and/or market orientation may help firms to face this dilemma (Leonard Barton, 1992; Danneels, 2002; Kyriakopoulous and Moorman, 2004; Atuahene-Gima, 2005). However, attempts to achieve ambidexterity continue a challenge, so remains the need for additional conceptual efforts and empirical investigations about how firms can be ambidextrous.

In this study, we examine how product development contributes to ambidexterity by balancing the exploitation of existing competences and the exploration of new ones and, then, the consequences for product development performance. As technology management has become ingrained within the field of knowledge management (KM), product development has been viewed from a knowledge management perspective. Thus, KM provides a basis upon which building a theory of product development (Fedor et al., 2003; Madhavan and Grover, 1998). In the same way that exploration and exploitation are different logics that require very different structures, processes and cultures (He and Wong, 2004), knowledge management literature has often defended the role of socio-organizational and technological factors in the management of knowledge processes (Gold et al., 2001; Lee and Choi, 2003; Chuang, 2004). Specially, information systems and technologies have been considered as a reference discipline for both product development (Nambisan, 2003) and knowledge management.

On this basis, we analyse the link between one specific kind of knowledge management enabler, the information technology (IT), and ambidexterity in product development. We thus suggest that IT can promote the balance of exploration and exploitation activities and, thus, ambidexterity in the development of new products. In so doing, the role of information technologies goes from the transaction, organizing and processing of knowledge to the facilitation of coordination, people networks and collaboration (Van den Brink, 2003). Thus, in this study IT is defined as (1) convergent, which are those focused on enhancing analysis and discourse, and supports a virtual network that is not constrained by barriers of time and place, and (2) divergent, which are about is about having information and explicit knowledge components online, indexed and mapped, with easy access and accurate retrieval for all members of product development. We argue that the interaction between both explorative and exploitative activities during product development emerges enhanced by the combination of the convergent and divergent dimensions of IT. As a result, performance of product development is achieved from ambidexterity through the balance exploration-exploitation which, besides, mediates the relationship between IT and product development performance. These relationships are depicted in Figure 1.

Insert Figure 1 about here

By empirically examining these relationships, our study contributes to existing research in several ways: First, this study adds to previous empirical research the analysis of the interactive effect of exploitation and exploration in product development, which determines the nature of their balance (Atuahene-Gima, 2005), and provides addition insights into pursuing ambidexterity in product development. Second, our study examines how combinations of different IT dimensions lead product development projects that pursue exploratory and exploitative actions simultaneously. Third, we examine the mediating role of ambidexterity in the success of product development performance.

In the body of this paper, we begin by describing the nature of ambidexterity in product development and establish its value by examining its relation to performance in product development. We follow with the role of information technologies as antecedents of ambidexterity. We also propose that ambidexterity mediates the relationship between information technologies and performance in product development. We then present our empirical analysis where we test and support our hypotheses. Finally, we discuss our empirical findings.

AMBIDEXTERITY IN PRODUCT DEVELOPMENT

The need of the appropriate balance between exploration and exploitation activities has been crystallized by Tushman and O´Reilly's (1996) conceptualization of ambidextrous organizations, which have the capability to operate simultaneously by both exploring and exploiting opportunities. Gibson and Birkinshaw focus on contextual organizational ambidexterity, defined as "the capacity to simultaneously achieve alignment and adaptability (2004: 1)". The concept of ambidexterity is also implicit in the more recent concept of dynamic capabilities that, as suggested by Eisenhardt and Martin (2000), require a blend of two different strategic logics, namely the logic of exploration and the logic of exploitation. Exploration and exploitation form a dynamic path of absorptive capacity (Zahra and George, 2002) and a continuum ranging that shape organizational learning (March, 1991; Crossan et al., 1999). And in product development/innovation research, scholars often study the degree of independence and iterative effects between exploration and exploitation (Lawson and Samson, 2001; Katila and Ahuja, 2002).

We analyse ambidexterity in the particular context of product development. The essence of product development is the exploration and exploitation of knowledge throughout a problem resolution process aimed to create products that have value in the marketplace (Mohrman et al, 2003). In ideal situations, individuals involved in product development have a specialized knowledge that frames their attention when they approach a problem. Accordingly, product development requires a high degree of members' involvement in problem recognition and resolution processes. In the first step, members must construct meaning about environmental changes, and the recognition of the existence of a problem occurs when some stimuli indicate the need for new actions. These stimuli then lead to the second step, when members jointly deal with work processes, tasks, technological characteristics etc. to solve the problem. Knowledge exploitation occurs with the utilization of existing knowledge for innovative problem solving. Knowledge exploration occurs when existing knowledge is not sufficient to solve the problem identified and tends to construct and acquire new knowledge, with contribution to the body of knowledge. In other words, by recognizing and defining problems, and applying knowledge to solve problems, individuals generate new knowledge, both tacit and explicit (Nonaka, et al., 2000).

We thus accept that product development appears to involve ambidexterity by simultaneously exploring and exploiting knowledge. Product development exhibits an experience effect that includes the application of past experience and competences, even in the product development process itself, which represents the exploitation of past knowledge within the firm. Moreover, repeatedly using the same knowledge elements reduces the likelihood of errors and false starts and facilitates the development of familiar routines (Levinthal and March, 1993) that allows the decomposition of sequenced activities in an efficient order where unnecessary steps can be eliminated (Eisenhardt and Tabrizi, 1995). It also leads to a deeper understanding of concepts, booting the firm's ability to identify valuable knowledge within them, develop connections between them and combine them in many different and significant ways (Katila and Ahuja, 2002). Similarly, product development may also lead to move away from current organizational routines and knowledge bases because of exploration (March, 1991). Knowledge exploration introduces variations needed to provide a sufficient amount of choices to solve problems (March, 1991), improves the possibility of engendering new ideas or creating new knowledge combinations, and allows obsolete knowledge substitution. For example, exploration is especially intense at the development initiation of new product development, or when well known solutions to specific problems are ineffective or too costly to develop.

Although near consensus exists on the need of ambidexterity, there is considerable less clarity on how the balance between exploration and exploitation activities may be achieved (Jansen et al. 2005). Firms fail or succeed when combining exploration and exploitation because they differ in how they manage the requirements that a productive combination demands. It is considered that the logic under ambidexterity is the integration of contrasting organizational characteristics (Benner and Tushman, 2003). Tushman and O´Reilly (1996) describe ambidexterity in structural terms, suggesting that ambidextrous organizations encompass separate structures, some focused on exploration and some focused on exploitation. Gibson and Birkinshaw (2004) approach the challenge of ambidexterity from the perspective of the individual employees, suggesting they need a collective organizational context in order to simultaneously demonstrate alignment and adaptability during their day-to-day work. Jansen et al. (2005) analyse the importance of environmental and organizational antecedents on ambidexterity, finding that decentralization and connectedness are significant to the ability of firms to simultaneously pursue explorative and exploitative innovations.

We suggest that, if product development exhibiting ambidexterity is expected to lever, manipulate, and combine structural and social characteristics to create a proper framework to simultaneously explore and exploit knowledge, it is logic to presume that IT may have also a role to play. Specifically, we hypothesize that the extent to which product development pursue both exploration and exploitation simultaneously, and thus achieve ambidexterity, is shaped by the integration of contrasting IT dimensions. We also hypothesise about the impact of ambidexterity on product development performance, including its mediation effect in the relationship between IT and product development performance.

AMBIDEXTERITY AND PERFORMANCE

Just knowing that product development involves ambidexterity by balancing both knowledge exploration and knowledge exploitation activities is not particularly compelling. What makes this of particular interest is that ambidexterity may significantly affect product development performance.

Really, there is an essential way to enlarge an organization's performance, and it is through the identification and satisfaction of market demands and customers' expectations (Neely and Adams, 2001). Firms create value by installing knowledge in products and services, applying new knowledge to old problems, synthesizing discrete kinds of existing knowledge, and globalizing deeply embedded local knowledge (Anand and Khanna, 2000). Knowledge is at origin of most improvements in customer value (Anderson and Narus, 1998). Therefore, organizations must use knowledge generated through product development to provide vital products and services to its customers, making it harder for them to switch to another supplier. In doing so, organizations need to have knowledge of customer's needs in order to sense and act upon trends in the market. It implies using knowledge to generate new strategic opportunities. As result, firms try to do more and better than rivals and to come up with ways to offer customers lower prices or superior quality.

In order to guarantee better performance and maximize the fit with customer needs, product development must also take into account the firm's competences. Successful firms are those able to match their new developments goals and their internal resources and competences (Schilling and Hill, 1998). The matching of complex customer requirements to engineering and manufacturing capabilities is fundamental in the generation of customer value. Collaboration and coordination is greatly facilitated when product development integrates common knowledge of both customer requirements and engineering/manufacturing capabilities. This is important in order to launch new products to market on time. In this respect, Sharki (2003) proposes that the speed of firm's generation, dissemination, and use of knowledge to develop new and hard-to-imitate operational capabilities is critical for firm performance.

In view of this, product development performance may be considered a multidimensional concept. In this study, product development measures are classified into two components: (1) *process outcomes* analyze the effectiveness of the product development process and the degree of collaborative behaviour of product development team (Zirger and Maidique, 1990) and (2) *product outcomes* concern the characteristics associated with products and the product success in the market place (Clark and Wheelright, 1995).

As we just see, the firm's internal competences highlight the importance of knowledge accumulation and exploitation. Given the strong cumulative nature of scientific knowledge, the firm's base of knowledge prior to the product development influences the effective acquisition and utilization of new knowledge (Cohen and Levinthal, 1990). Knowledge facilitates the use of other knowledge. Then, firms that possess relevant prior internal competences to value and apply knowledge likely develop products with a better level of integration and understanding of new knowledge. Product development involving higher levels of exploitation will have superior performance in terms of process outcomes. With experience, product development becomes more proficient at acquiring, disseminating, processing, and assimilating information.

Firms that choose to be leaders in knowledge exploration require greater knowledge development, beyond the current knowledge base and zone of comfort of the firm. By effectively applying this knowledge, product development might be able to build and launch to market more creative new products. So, the firm is not likely to miss the opportunity created by emerging market demand because it has the knowledge and ability to better understand and anticipate customer needs. These product developments also question their well-operated internal capabilities, and update fundamental operating philosophies. Such behaviours and strategies should provide more value for customers than their competitors and lead to superior long-term performance.

Then, exploitation activities are basically geared towards improving effectiveness of the product development process and exploration activities are geared toward improving product and its success in the market place. Exploitation is focus on short term performance and exploitation is more focus on long term performance. If product development focuses on one of these at expenses of the other, problems and tensions will inevitably arise. Following March (1991), while product development that engages in exploration and exclude exploitation is likely to suffer the cost of experimentation without gaining many of the benefits, product development that engages in exploitation to the exclusion of exploration is likely to find themselves trapped in suboptimal equilibrium.

Likewise, low levels in both knowledge exploration and exploitation do not lead to enhance much product development performance. On the contrary, when product development has a proper alignment between knowledge exploration and exploitation, exhibiting high levels of ambidexterity, it may have a very positive association with improved product development performance in terms of process and product. In fact, this alignment involves a product development potential to identify valuable knowledge and to combine it efficiently with prior knowledge in such a way that performance is improved. Hence, we propose the following hypotheses:

H1: The higher the level of ambidexterity in product development, the higher level of performance measured in terms of product and process.

INFORMATION TECHNOLOGIES AND AMBIDEXTERITY

At this point, the question is: How does product development may achieve ambidexterity?. Ambidexterity in product development depends not only on how effectively the diverse individuals are able to organize and develop their unique knowledge competences, but also on how they can integrate and use their distinctive knowledge both effectively and synergistically to create a collaborative, ongoing learning. Accordingly, researchers and practitioners strive for clues on how to manage ambidexterity effectively and to design and create an organizational context for the work that makes members of product development attend to different information, attach new meanings, and try new approaches as they make sense of their technical problems.

Today, there is a lot of discussion on how to manage ambidexterity, due to baffling approaches coexisting about it. Throughout this discussion, IT is often pointed out as the anchor to achieve both exploration and exploitation (Davenport and Prusak, 1998; Scott, 2000; Alavi and Leidner, 2001; Gold et al., 2001) and thus to develop ambidexterity (Sher and Lee, 2004). As a knowledge management initiative, IT is the advanced infrastructure that enhances the volume of data, information and knowledge that can be processed throughout product development.

Previous research has supported that IT is a crucial element for knowledge related activities (Alavi and Leidner, 2001; Nonaka and Takeuchi, 1995). IT is accepted as a real pipeline to codify, organize and disseminate information and knowledge. At the same time, they can create an interconnected environment that is a medium to vertically and horizontally integrate efforts within product development, and in this way to shorten the length of the transformation cycles. As result, and based on the works of Van den Brink (2003), an effective information technology infrastructure demands a combination of two related dimensions: the convergent and the divergent dimension.

The divergent dimension is about having information and explicit knowledge components online, indexed and mapped, with easy access and accurate retrieval for all members of product development. It greatly affects how data and information are gathered and stored. In this situation the emphasis is put on explicit knowledge. The convergent dimension plays the role of enhancing analysis and discourse, and supports a virtual network that is not constrained by barriers of time and place. It improves coordination and communication between members of product development by transferring knowledge from those who posses it to those who need or can use it. Here the emphasis is on tacit knowledge.

Several tools are present at the divergent dimension: integrated document management, document imagining, data warehouse, data mining, business intelligence, intranet, and internet. These tools hold collections of knowledge components that have a structured content like manuals, reports, articles, best practices, customer inquiries and needs, competitor analysis and experience with production. A content classification scheme or taxonomy is used to organize knowledge, facilitate grouping, sorting visualization, searching, publication, manipulation, refinement and navigation. It mostly helps to explicit knowledge, since it can be expressed in symbols and communicated through these symbols to other people. It can be easily accessed and used by product development's members.

Regarding the convergent dimension, its functionality is incorporated in tools as e-mails, calendaring and scheduling, groupware, work management system, process support system, etc. Its goal is to facilitate group and teamwork regardless of time and geographic location. It offers product development members the opportunity to interact and exchange views and thoughts with each other. It is thus useful to transfer tacit knowledge –the one that is difficult to express and communicate to other people because it cannot be codified and articulated.

Both the convergent dimension and the divergent dimension configure the potential of IT to support product development' capability to generate and utilize knowledge. Therefore, it is feasible to presume that the relationship between the convergent dimension and the divergent dimension may produce variations in ambidexterity. While some companies tend to emphasize one dimension over other, other companies are able to manage the correct balance between both dimensions, or even adjust them in accordance with knowledge characteristics or environmental conditions. Following Zollo and Winter (2002), exploration activities are primarily carried out through cognitive efforts aimed at generating a necessary range of new intuitions and ideas as well as selecting the most appropriate ones through legitimation processes. By contrast, exploitation activities rely more on behavioural mechanisms encompassing the retention and replication of knowledge in conditions more or less similar to past ones. That being so, we may assume that convergent technologies are especially supportive of exploration activities as long as it facilitates knowledge sharing and amplification by bringing experts together. This dimension of IT supports communication and discourse among members of a product development effort, so they can contribute to and share their knowledge, intuitions and ideas. So, convergent IT may increase knowledge exploration by enabling a knowledge space for constructing and sharing beliefs, for confirming consensual interpretation, and for allowing expression of new ideas (Alavi and Leidner, 2001), so that individuals may arrive at new insights and/or more accurate interpretations than they would do by their own.

Conversely, divergent technologies are more supportive of exploitation activities as long as they can enhance knowledge integration and application by facilitating the capture, updating, and accessibility of existing knowledge (Alavi and Leidner, 2001). So, this dimension of IT may be considered as a “memory aid” that helps in storing and reapplying workable solutions in the form of standards and procedures. This retrieved knowledge can be easily used as input for intelligent agents, which replicate prior procedures to solve recurring problems. It also increases the speed at which existing knowledge can be accessed and applied, both in a structured and unstructured form (Robey et al., 2000). Moreover, divergent IT has been designed to retrieve and use knowledge directly, without human intervention. While human intervention is a prerequisite for knowledge exploration, it is not for knowledge exploitation.

Then, when conceptualized in the way described above, we argue that the developing ambidexterity require the combination of the convergent and divergent dimensions of IT. While exploitation demands essentially the divergent dimension of IT, exploration is basically supported by the convergent dimension. We may thus enunciate the following hypotheses:

H2. The more that information technology is characterized by a combination of convergent and divergent technologies, the higher the level of ambidexterity.

MEDIATION EFFECTS

Finally, we argue that ambidexterity mediates the relationship between convergent and divergent dimensions of IT and product development performance. That is, the attributes of IT influence product development performance through the achievement of ambidexterity. When ambidexterity has not been developed in product development (that is, when product development does not imply the capacity to simultaneously explore and exploit knowledge), IT may or may not influence performance.

The ability to obtain, process and use information and knowledge about markets and customers helps to ensure that firms are more familiar to environmental changes and can result in a competitive advantage (Tippins and Sohi, 2003). This is the reason why many firms have invested in IT focused strategies to gain competitive advantages. However, even when IT has become a competitive necessity for most of the firms, there is no perfect understanding of how IT competencies impacts performance. Studies examining the association between IT and performance differ in how they conceptualise key constructs and relationships (Melville et al., 2004). It has been argued that IT by itself is ineffective at providing a basis for sustainable competitive advantage because these competences could be easily replicated by competitors. It is also considered that IT is valuable, but the extent and dimensions are dependent upon other complementary organizational characteristics. In example, Tanriverdi (2005) suggests that knowledge management is a critical organizational capability through which IT influences performance. Bharadwaj (2000) analyse the association between superior IT capabilities and superior performance by defining IT capabilities as the synergistic combination of IT resources co-present with other organizational resources and capabilities. And Melville et al. (2005) sustain that IT impact performance via intermediate business processes.

Therefore, it would be wrong to suggest that a firm could simply institute (or imitate) the two applications of IT and expect them to deliver superior performance. Rather, we consider that the impact of IT on performance in product development initiatives must be quantified by examining the indirect effect of some interesting firm competences, as it is the capacity for ambidexterity. Accordingly, we simply hypothesize that:

H3. Ambidexterity mediates the relationship between information technology –as captured by the combination of convergent and divergent technologies- and product development performance.

RESEARCH METHODOLOGY

Sample characteristics and data collection

Survey methodology has been used for the empirical analysis. The questionnaire has been designed and developed from a thorough literature review, and simplified by us in some indicators. The questionnaire was validated through a pre-test that was carried out through several personal interviews with product development executives. These interviews allowed us to purify our survey items and rectify any potential deficiency. Minor adjustments were made on the basis of specific suggestions.

After the pilot study, the mailing list was obtained from Madri+d[1]. Respondents were product development managers, selected according to a representative population approach, and contacted by telephone or mail. Those who agreed to participate in the study received the questionnaire by e-mail or by accessing a web page where they could find the questionnaire. They had to answer to questions related with a specific product development. A researcher involved in the study personally helped to the product development managers to solve the

[1] Madri+d is a society that groups firms and public research organizations aimed of improving of competitiveness through encouraging research, development, innovation and knowledge transfer.

question related to the survey. This implies that sample characteristics were not significantly different from the corresponding population parameters of the original sample provided by Madri+d. As a result, 80 products development managers provided responses. In term of industry type, we covered a wide number of industries. Table 1 summarizes respondent characteristics in terms of total number of employees.

Insert Table 1 about here

Since it was a large survey, in this research we only chose the questions that helped investigate the hypotheses detailed above. In our particular case, a first set of questions were related to define the IT configuration. The second set of items was associated to ambidexterity and the third one to performance.

Measures description

The measurement of the analysis variables has been built on a multiple-items method, which enhances confidence about the accuracy and consistency of the assessment. Each item was based on a five point Likert scale and all of them are perceptual variables. Table 2 displays items used to measure the analysis variables.

Insert Table 2 about here

Ambidexterity

Although we conceptualized ambidexterity as a multidimensional construct comprised of the nonsubstitutable combination of exploration and exploitation (that is, the multiplicative interaction of both activities), we anticipated that post hoc analysis might involve the examination of these activities independently as well as in combination. Therefore, we began by constructing separate scales for exploration and exploitation. As stated by Crossan et al. (1999), exploration takes place when product development generates new knowledge. Likewise, exploitation encompasses processes that take and transmit embedded knowledge that has been learnt from the past down to product development. Accordingly, and based on Lee and Choi (2003), Mohrman et al. (2003) and Katila and Ahuja (2002), ambidexterity have been measured by using 8 items, four items concerning to exploration and four items concerning to exploitation. The first four items measured the degree to which the product development introduce new ideas, new knowledge and cover and correct problems areas where customers were unsatisfied. The last four items measured the degree to which the product development introduces lessons learnt in the past, existing competences, and combines and integrate different knowledge.

Information Technology

As we have previously argued, we measure IT in product development from a convergent and divergent perspective. In a post hoc analysis we also examined these dimensions independently and in combination. Based on Lee and Choi (2003) and Gold et al. (2001), IT was operationalized by using nine items. Convergent dimension was assessed by the degree to which IT foster communication and collaboration between people related to product development inside and outside organization (four items). IT divergent dimension was measured by the degree to which IT facilitates rapid collection, storage, mapping and formatting knowledge and, thereby assisting the knowledge creation in product development (five items).

Performance

The dependent variable was measured through two components: Teamwork values process outcomes and market performance expresses product outcomes. Specially, to capture process outcome, we ask product development managers to indicate the extent to which the product development team worked well together, coordinated activities well, implemented decisions effectively, was productive, used financial resources sensibly, used all product developments resources rationally and used product engineering hours efficiently. These items were previously used by Hong et al. (2005) who drawn them from Alder (1995), Ali et al. (1995), Crawford (1992) and Tersine and Hummingbird, (1995). To capture product outcomes we ask our respondents to reflect on market performance and indicate in a five point Likert scale, the degree to which they were satisfied with the market performance of the product (Hong, 2000).

ANALYSIS AND RESULTS

Data analysis has involved several steps. First, since our research variables are measured through multiple-item constructs, we need to verify that items tapped into their stipulated construct. Thus, we conducted three independent factorial analyses by using SPSS 13.0 for Windows: one for ambidexterity –exploration and exploitation- items, other one for IT dimensions items, and a last one for process performance items. Results obtained were factors that condense the original nominal variable information while providing continuous variables for each group of variables. Table 3 summarizes these results. The internal consistency measures (Cronbach's alpha) were obtained in order to assess the reliability of the measurement instruments. In a last step in constructing our measures, we computed the interaction between exploration and exploitation, reflecting our argument that they are interdependent and nonsubstitutable. In the same way, we also created an interaction term using the multiplicative interaction of the convergent and divergent dimensions of IT, reflecting our argument that these should be considered holistically and complementary.

Insert Table 3 about here

Second, means, standard deviation, and correlations among the variables are shown in table 4. Ambidexterity was significantly and positively correlated with performance, with teamwork showing the strongest correlation. Furthermore, ambidexterity was highly correlated with IT combination and this last variable was also significantly and positively related to performance. Essentially, correlations provide evidence that performance is related to ambidexterity and IT combination; however our subsequent analysis investigate the complexity of these relationships as mediated by ambidexterity.

Insert Table 4 about here

Then, we tested the hypotheses using ordinary least square (OLS) regression. Hypothesis 1 predicts that ambidexterity (that is, the multiplicative interaction of exploration and exploitation) will be positively related to performance. As depicted in Table 4, the beta coefficient for ambidexterity in Model 1 and model 2 were positive and significant (Model 1. Beta=.41, p<.001), (Model 2 Beta=.26, p<.05), supporting Hypothesis 1. Hypothesis 2 predicts that IT (the multiplicative interaction of dimensions of IT) would be positively related to ambidexterity. As shown in model 3, this prediction also was supported (Beta=.41, p<0.001).

Insert Table 5 about here

Hypothesis 3 predicts that ambidexterity will mediate the relationship between IT -as captured by the convergent and divergent dimension- and performance. Analyzing mediation involves three steps (Baron and Kenny, 1986; Gibson and Birkinshaw, 2004; Kenny et al., 1998; Mackinnonand Dwyer, 1993). The first step is to establish that the independent variable (here, IT) influence the mediator (ambidexterity). This step was supported by model 3. The second step is to demonstrate that the independent variable (IT) influences the dependent variable (performance in terms of teamwork and market performance). This step was supported in model 4 and 5 of Table 5. IT had a significant positive relationship with performance in terms of process and product (Model 4. Beta=.23, p<.05), (Model 5 Beta=.20, p<.1). Lastly, one must demonstrate that the mediator (ambidexterity) influences the dependent variable, with the independence variable (IT) controlled. If, in this final step, the effect of the IT in performance is no longer significant when the mediator is in the model, full mediation is indicated (Baron and Kenny, 1986; Gibson and Birkinshaw, 2004; Kenny et al., 1998).

As shown in model 6 and 7, the coefficient for ambidexterity was positive and significant in both cases, indicating a main effect of ambidexterity on performance. Further, with ambidexterity in the equation, the coefficient for IT was no longer significant. Both the size of the coefficient for IT and the corresponding test statistic for significant differences (t) decreased from model 4 and 5 (Model 4. Beta=.227, t= 2.02, p<.05), (Model 5 Beta=.20, t=1.75, p<.1) to model 6 and 7 (Model 6. Beta=.07, t= .56, n.s.), (Model 7 Beta=.12, t=0.96, n.s.). We tested the statistical significance of the mediated effect by dividing it by its standard error[2], thus obtaining a Z-score (Baron and Kenny, 1986; Kenny et al., 1998; Mackinnon and

---

[2] According to Kenny et. al. (1998:260) "The amount of mediation is defined as the reduction of the effect on the initial variation on the outcome. This difference in coefficients can be shown to equal exactly the product of the effect of X on M times the effect of M on Y or $\alpha * \beta$. Note that the amount of reduction in the effect of X on Y is not equivalent to either the change in the variance explained or the change in an inferential statistic such as F or p value". If steps 2 and step 3 are met, it follows that there necessarily is a reduction in the effect of X on Y. An indirect and approximate test that $\alpha * \beta = 0$ is to test that both $\alpha = 0$ and $\beta = 0$ (steps 2 and 3). Baron and Kenny (1986) provided a direct test of $\alpha * \beta = 0$ which is a modification of a test originally proposed by Sobel (1982). The statistic propose to conduct the test is given by $z = a * b / \text{sqrt}(a^2 * S_b^2 + b^2 * S_a^2 + S_a^2 * S_b^2)$ where *a* and *b*

Dwyer, 1993). The mediated effect was statistically significant in both cases (Z=3.84 for teamwork; Z=2.28 for market performance), supporting the full meditation proposed in Hypothesis 3.

Post hoc analysis

To further verify our findings and gain additional insights, we conducted several post hoc analyses. The scatter graph of exploration and exploitation suggested the possibility of identifying some meaningful clusters, so we undertook some cluster analysis to facilitate the specification of groups. In our case we applied a Ward's hierarchical method using the Euclidean distance and an agglomeration schedule to determine the number of clusters and the initial seeds (centres of the groups) that were introduced in a second K-means no hierarchical analysis which provided the final categorization of the firms.

Insert Table 6 about here

The characterization of the clusters based on the final centres of K-means analysis is displayed in Table 6. Cluster 1, including 46 product development projects with low exploration and exploitation, represents a *lowly ambidextrous product development*. Cluster 2, comprising 17 product developments characterized by high exploitation but very low exploration, presents an *exploitation-based* product development. Cluster 3, formed by 15 product developments, shows a high exploration and exploitation. It clearly represents a *highly ambidextrous product development*. Table 6 also shows the non-existence of product development with low emphasis on exploitation. This result illustrates the strong cumulative nature of scientific knowledge.

Insert Table 7 about here

Next, the relationship between exploration and exploitation and product development performance was analyzed within each cluster. Table 7 shows descriptive statistics (mean and deviation values) and ANOVA test for the segmented configurations. The ANOVA F-test was highly significant and indicated that we could reject the null hypothesis that all three groups have the same performance level [F=3,66, $p<0.05$]. Product developments included in highly ambidextrous group (cluster 3) was the best performing (highest mean value), followed by exploitation-based (cluster 2) and lowly ambidextrous (cluster 1). This result provided additional support for our framework, suggesting that the ability to be ambidextrous is an important predictor of performance.

We also applied a cluster analysis to the factors of the IT dimensions. This cluster analysis led us to define different IT configurations in terms of the convergent and divergent dimensions. Again both IT measures had discriminatory power.

---

are estimates of α and β respectively. The z-statistic under the null hypothesis has approximately a Normal distribution; therefore values larger than 1.96 in absolute value permit to reject the null hypothesis at 0.05 significance level.

Insert Table 8 about here

Table 8 displays the characterization of the clusters based on the final centres. Cluster 1, including 44 product developments with high convergence and divergent IT dimensions, represents a *balanced IT configuration*. Cluster 2, comprising only 10 product developments characterized by high convergent IT dimension but very low divergent IT dimension, represents a *convergent-based IT configuration*. Cluster 3, formed by 24 product developments, differs from the other two groups in its convergent dimension as it is very low. Although the divergent IT dimension of this group shows more variability when compared to the other two clusters, it clearly shows a *divergent-based IT configuration*. Table 8 also shows the no-existence of product development with low emphasis on both convergent and divergent IT. This result do points the recognition of information technologies in enabling learning and knowledge sharing in product development.

The relationship between performance and IT configurations in product development was also analyzed within each cluster/configuration. Table 9 shows descriptive statistics (mean and deviation values) and ANOVA test. Again the ANOVA F-test was highly significant and indicated that we could reject the null hypothesis that all three groups have the same performance level [$F=6{,}96$, $p<0.01$]. Product developments included in balance IT configuration (cluster 1) was the best performing (highest mean value), followed by divergent-based (cluser 3) and convergent-based IT configuration (cluster 2). This result also provided additional support for our framework. Balance IT configuration outperforms clearly those that were convergent-based IT configuration and divergent-based IT configuration, suggesting that the ability to have both IT dimensions is also an important predictor of performance.

Insert Table 9 about here

DISCUSSION

In this study, we have adopted a multi-method approach to understanding the mediating role of ambidexterity in the success of product development, while presenting IT as driver that can promote the balance of exploration and exploitation activities. We found strong evidence that ambidexterity –the simultaneous achievement of exploration and exploitation- mediates the relationship between the IT that encourage these activities and subsequent performance in product development.

In this study we adopted the recent focus on a paradoxical approach to management (Lewis, 2000; Gibson and Birkinshaw, 2004) and introduce the concept of ambidexterity in product development. In fact, product development does not seem to involve a trade off between exploration and exploitation, whereby one is at the expense of the other. Successful product developments are able to simultaneously develop both knowledge activities. Traditionally, research has focus on what product development occurs in two extreme forms. In the first situation, the developing knowledge comes from the existing knowledge (exploitation). In the second situation new knowledge is created with loose connections to existing knowledge (exploration). According to this, certain product development are designated as responsible for exploration and other others are designated as responsible for exploitation. Conversely, we defend the hypothesis of ambidexterity in product development.

Our results indicate that achieving ambidexterity in product development through IT – as captured by the convergent and divergent dimension- is possible and does relate positively to performance. Furthermore, it is not enough to simply use IT. It is when these supportive technologies create the capacity for ambidexterity that performance gains are realized. In order to support exploitation in product development, the question is to retrieve and combine knowledge that may be distributed across different departments or organizational units. This may not necessarily imply to connect people, but convergent IT gives "flexibility" to divergent IT because knowledge is complex in nature and it is very often related to individuals who posses it. Thus balanced combinations of convergent and divergent IT dimension allow the elimination of structural and temporal barriers, and allow distributed participants in product development to collaborate and coordinate the work in an interactive way. It also supports knowledge location, within and outside the organization, so that available knowledge can be mapped in an internal knowledge base. It is the delicate balance among both the convergent and the divergent dimensions of IT which most affects ambidexterity in product development. Thus, the implications for the management practice is that ambidexterity is likely an important and desirable capability that product development can develop, and that it can be shaped at least in part through IT.

Our results must be viewed in the light of the study's limitations. First, sample size is not large. As a second limitation, it is necessary say that we have tried to define our constructs as precisely as possible by drawing on relevant literature and to closely link our measures to the theoretical underpinnings through a careful process of item generation and refinement. Evidently, this measurement effort represents an advance for research but, nonetheless, our research items are far for being perfect as long as they measure facts that are neither fully nor easily measurable. Another limitation concerns the fact that all data were collected from the same respondent using the same perceptual measurement technique. Although our findings may help to explain certain relationships between variables, we are aware that replies from multiple respondents would have ruled out potential drawbacks. We should also have in mind that both the external environment and the organization's internal characteristics naturally interferes with product development efforts, therefore amplifying or attenuating the organization's tendency to explore and/or exploit. This work is thus obviously only a preliminary step towards a better understanding of impact of IT and ambidexterity, on the basis of previous limitations; it naturally points out avenues for future research.

REFERENCES

Adler, P.S., (1995). "From project to process management: an empirical based framework for analyzing product development time". *Management Science* 41 (3): 458-484.

Adler, P.S., Goldoftas, B., Levine, D.I. (1999). "Flexibility Versus Efficiency? A Case Study of Model Changeovers in the Toyota Production System". *Organization Science*, 10 (1): 43-68.

Alavi, M. and Leidner, D.E. (2001). "Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues". *MIS Quarterly,* 25 (1): 107-136.

Ali, A., Krapfel, R., Jr. ,LaBahn, D.,(1995). "Product Innovativeness and entry strategy: Impact on cycle time and break-even time". *Journal of Product Innovation Management* 12 (1): 54-69.

Anand, B. N. and Khanna, T. 2000. "Do firms learn to create value: The case of alliances". Strastegic Management Journal, 21: 295-315.

Anderson, J. C. and Narus, J.A. (1998). "Business Marketing: Understand What Customers Value". *Harvard Business Review*. (November-December): 53-67.

Atuahene-Gima, K. (2005). "Resolving the Capability-Rigidity Paradox in New Product Innovation". *Journal of Marketing*, 69: 61-83.

Auh, S. and Menguc, S. (2005), "A Test of Strategic Orientation Formation vs. Strategic Orientation Implementation: The Influence of TMT Functional Diversity and Inter-functional Coordination," *Journal of Marketing Theory and Practice,* 13 (2): 4-19.

Baron, R.M. and Kenny, D.A. (1986). "The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations". *Journal of Personality and Social Psychology*, 51:1173-1182.

Baron; R. M. and Kenny, D.A. (1986). "The moderator-mediator variable distinction

Benner, M.J. and Tushman, M.L. (2003). "Exploitation, Exploration and Process Management: The Productivity Dilemma Revisited". *Academy of Management Review*, 28 (2): 238-256.

Bharadwaj, A. (2000). "A Resource-Based Perspective on Information Technology Capabilities and Firm Performance: An Empirical Investigation". *MIS Quarterly, 24 (1)*: 169-196.

Bierley, P. y Chakrabarti, A. (1996): "Generic Knowledge Strategies in the U.S. Pharmaceutical Industry". *Strategic Management Journal*, 17 (winter special issue): 123-135.

Chuang, S. (2004). "A Resource-Based Perspective on Knowledge Management Capability and Competitive Advantage: An Empirical Investigation". *Expert Systems with Applications*, 27: 459-465.

Clark, K.B. and Wheelwright, S.C. (1995): "Leading product development". The free press, New York.

Cohen, W. M.; Levinthal, D. A. (1990). "Absorptive-Capacity - A New Perspective on Learning and Innovation". *Administrative Science Quarterly*, 35 (1): 128-152.

Crawford, C.M. (1992). “The hidden cost of accelerated product development”. *Journal of Product Innovation Management* 9 (3): 188-199.

Crossan, M.M., Lane, H.W. and White, R.E. (1999). ‘An Organizational Learning Framework: from Intuition to Institution’. *Academy of Management Review*, 24 (3): 522-537.

Danneels, E. (2002). “The Dynamics of Product Innovation and Firm Competences”. *Strategic Management Journal*, 23 (12): 1095-1121.

Davenport, T.H. and Prusak, L. (1998). *Working Knowledge. How Organizations Manage What They Know*. Harvard Business School Press. Boston, Massachusetts. 1998.

Eisenhardt, K. M. and Martin, J.K. (2000). “Dynamic Capabilities: What Are They?”. *Strategic Management Journal*, 21: 1105-1121.

Eisenhardt, Kathleen M. and Behnam N. Tabrizi, (1995): "Accelerating Adaptive Processes: Product Innovation in the Global Computer Industry", *Administrative Science Quarterly*, 40: 84-110.

Fedor, D.B., Ghos, S., Caldwell, S.D., Maurer, T.J. and Singhal, V.R. (2003). “The Effects of Knowledge Management on Team Members' Ratings of Project Success and Impact”, *Decision Sciences*, 34 (3): 513-539.

Ghemawat, P. and Costa, J.E. (1993). “The Organizational Tension Between Static and Dynamic Efficiency”. *Strategic Management Journal*, 14: 59-73.

Gibson, C. B. and Birkinshaw, J. (2004). “The Antecedents, Consequences, and Mediating Role of Organizational Ambidexterity”. *Academy of Management Journal*, 47 (2): 209-226.

Gold, A.H., Malhotra, A. and Segars, A.H. (2001). “Knowledge Management: An Organizational Capabilities Perspective”. *Journal of Management Information Systems*, 18 (1): 185-214.

He, Z. and Wong, P. (2004). “Exploration vs. Exploitation: An Empirical Test of the Ambidexterity Hypothesis”. *Organization Science*, 15 (4): 481- 494.

Hong, P (2000). “Knowledge Integration in Integrated Product Development”. Doctoral Thesis. University of Toledo, USA

Hong, P., Vonderembse, M., Doll, W. J, & Nahm, A. (2005). „Role Changes of Design Engineers in Integrated Product Development”. *Journal of Operations Management*, *24*(1): 63-79.

in social Psicology research: Conceptual, strategy and statistical considerations”. *Journal of Personality and Social Psicology*, 51:1173-1182.

Janse, J.J.P., Van den Bosch, F.A.J. and Volverda, H.W. (2005). “Explorative Innovation and Exploitative Innovation, and Ambidexterity: The Impact of Environmental and Organizational Antecedents”. *Schmalenbach Business Review*, 57: 351-363.

Katila, R. and Ahuja, G. (2002). "Something Old, Something New: A Longitudinal Study of search Behaviour and New Product Introduction". *Academy of Management Journal*, 45 (6): 1183-1194.

Kenny, D.A., Kashy, D.A. & Bolger, N. (1998). "Data analysis in social Psicology". In D. Gilbert, S. Fiske&G. Lindzey (Eds.), *The Handbook of Social Psychology*, vol 1 (4th ed.): 233-265. Boston: McGraw-Hill.

Kenny, D.A., Kashy, D.A., & Bolger, N. (1998). "Data Analysis in Social Psychology". In D. Gilbert, S. Fiske, & G. Lindzey (Eds.). *The handbook of social Psychology*, vol. 1 (4th ed.):233-265.Boston:McGraw-Hill.

Kyriakopoulous, K. and Moorman, C. (2004). "Tradeoffs in Market Exploitation and Exploration Strategies: The Overlooked Role of Market orientation". *International Journal of Research in Marketing*, 21: 219-240.

Lawson, B. and Samson, D. (2001). "Developing Innovation Capability in Organisations: A Dynamic Capabilities Approach". *International Journal of Innovation Management*, 5 (3): 377-400.

Lee, H. and Choi, B. (2003). "Knowledge Management Enablers, Processes, and Organizational Performance: An Integrative View and Empirical Examination". *Journal of Management Information Systems*, 20 (1): 179-228.

Leonard Barton, D. (1992). "Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development". *Strategic Management Journal*, 13 (8): 111-125.

Levinthal, D.A. and March, J.G. (1993). "The Myopia of Learning". *Strategic Management Journal*, 14: 95-112.

Lewis, M.W. (2000). "Exploring paradox: Toward a more comprehensive guide". Academy Management Review, 25:760-777

MacKinnon, D.P. & Dwyer, J.H. (1993). "Estimating mediated effects in prevention studies". *Evaluation Review*, 17 (2):144-158.

Mackkinnon, D.P.,&Dwyer, J.H. (1993). "Estimating mediated effects in prevention studies". *Evaluation Review*, 17(2): 144-158.

Madhavan, R. and Grover, R. (1998): "From Embedded Knowledge to Embodied Knowledge: New Product Development as Knowledge Management". *Journal of Marketing*, 62, October: 1-12.

March, J.G. (1991). 'Exploration and Exploitation in Organizational Learning'. *Organization Science*, 2 (1), February: 71-87.

Melville, N., Kraemer, K. and Gurbaxini, V. (2004). "Review: Information technology and Organizational Performance: an Integrative Model of IT Business value". *MIS Quarterly*, 28 (2): 283-322.

Mohrman, S.A. and Finegold, D. and Mohrman, A.M (2003): "An Empirical Model of the Organization Knowledge System in New Product Development Firms". Journal of Engineering and Technology Management, 20: 7-38.

Neely, A. and Adams, C. (2001): "Perspectives on Performance: The Performance Prism". http: //www.som.cranfield.ac.uk/som/cbp/prismarticle.pdf.

Nonaka, I. and Takeuchi, H. (1995). *The Knowledge Creating Company*. Oxford University Press, New York.

Nonaka, I., Toyama, R. and Nagata, A. 2000. "A Firm as a Knowledge-Creating Entity: A New Perspective on the Theory of the Firm". *Industrial and Corporate Change,* 9 (1): 1-20.

Robey, D., Boudreau, M. and Rose, G.M. (2000). "Information Technology and Organizational Learning: a Review and Assessment of Research". *Accounting Management and Information Technologies*, 10, 125-155.

Schiling, M.A. and Hill, C.W.L. (1998): "Managing the new product development process: strategic imperatives", *Academy of Management Executive*, 12, 3: 67-81.

Scott, J.E. (2000). "Facilitating Interorganizational Learning with Information Technology". *Journal of Management Information Systems*, 17 (2):

Sharki, R. (2003): "Knowledge creation and its place in the development of sustainable competitive advantage". *Journal of Knowledge Management*, 7: 20-31.

Sher, P.J. and Lee, V.C. (2004). "Information Technology as a Facilitator for Enhancing Dynamic Capabilities through Knowledge Management". *Information & Management* 41: 933-945.

Sobel, M.E.(1982). "Asymptotic confidence intervals for indirect effects in structural equation model". In S. Leinhart (Ed.), *Sociological Methodology*: 219-312. San Francisco:Jossey-Bass.

Tanriverdi, H. (2005). "Information Technology Relatedness, Knowledge Management Capability, and Performance of Multibusiness Firms". *MIS Quarterly*, 29 (2): 311-334.

Tersine, R.J., Hummingbird, E.A. (1995). "Lead-time reduction the search for competitive advantage". International Journal of Operations and Production Management 12 (2):8-18.

Tippins, M. J. and Sohi, R.S (2003). "IT Competency and Firm Performance: Is Organizational Learning a Missing Link?". Strategic Management Journal, 24 (8): 745-761.

Tushman, M.L. and O´Reilly, C.A. (1996). "Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change". *California Management Review*, 38 (4): 8-30.

Van den Brink, P. (2003). "Social, Organizational and Technological Conditions that Enable Knowledge Sharing". Doctoral thesis, Technische Universiteit Delft, Amsterdam.

Zahra, S. A. and George, G. (2002). "Absorptive Capacity: A Review, Reconceptualization, and Extension". *Academy of Management Review*, 27 (2): 185-203.

Zirger, B. J. and Maidique, M. (1990). "A Model of New Product Development: An Empirical Test". *Management Science*, 36: 867-883.

Zollo, M. and Winter, S.G. (2002). "Deliberate Learning and the Evolution of Dynamic Capabilities". *Organization Science*, 13 (3): 339-351.

Figure 1. Relationships predicted

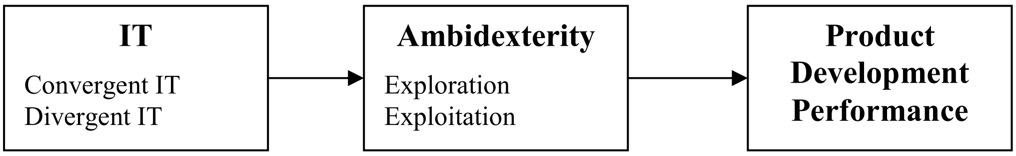

Table 1. Description of firms by total number of employees

Number of employees	Percentage
<= 499	65.8
500-999	9.6
1000-4999	12.3
5000-9999	6.8
>=10000	5.5
	100

Table 2. Items used to measure analysis variables

			Descriptive statistics	
Construct		Measurement item	Mean	S.D.
Information Tecnology	Divergent dimension	IT supports for systematic storing of information	4.04	0.94
		IT supports for mapping the location of knowledge and information	3.90	0.89
		IT supports for searching and accessing a high level of information about markets and competitors	3.70	0.91
		IT supports for clearly formatting its product knowledge	3.63	0.88
		IT supports for searching and accessing a high level of information about products and processes	4.01	0.65
	Convergent dimension	IT supports for collaborative work between people outside the organization	3.56	1.03
		IT supports for collaborative works between the people inside organization	3.57	0.89
		IT supports for communication among members inside the team of product development	4.00	0.75
		IT supports for communication with people outside the organization	3.94	0.82
Ambidexterity	Knowledge	Product problem areas with which customer were dissatisfied were corrected	3.3	0.9
		Problem areas with which customer were dissatisfied were covered	3.2	1.0
		New knowledge, methods and inventions were introduced	3.6	0.8
		Many new novel and useful ideas were produced	3.5	0.9
	Knowledge	The team was able to identify valuable knowledge elements, connect and combine them.	3.9	0.8
		It made use of existing competences related to products/services that are currently being offered.	3.9	0.8
		It was integrated new and existing ways of doing things without stifling their efficiency .	4.0	0.7
		Lessons learned in other areas of the organization were put in operation	3.9	0.9
Performance	Teamwork	The team used all product development resources rationally	3.6	0.7
		The team implemented decisions effectively	4.0	0.7
		The team used product engineering hours efficiently	3.6	0.9
		The team coordinated activities well	3.8	0.8
		The team used financial resources sensibly	3.5	0.9
		The team worked well together	4.1	0.7
		The team was productive	3.9	0.7
	Market performance	Degree of market performance of product development	4.0	0.8

Table 3. Definition of constructors and internal consistency measures

	Construct	Measurement item	Factorial analysis		
			Loading factor *	**Variance extracted (%)**	**Reliability (Cronbach's alpha)**
Information Tecnology	**Divergent dimension**	IT supports for systematic storing of information	0.85	28.18	0.82
		IT supports for mapping the location of knowledge and information	0.81		
		IT supports for searching and accessing a high level of information about markets and competitors	0.78		
		IT supports for clearly formatting its product knowledge	0.71		
		IT supports for searching and accessing a high level of information about products and processes	0.64		
	Convergent dimension	IT supports for collaborative work between people outside the organization	0.75	26.14	0.82
		IT supports for collaborative works between the people inside organization	0.75		
		IT supports for communication among members inside the team of product development	0.70		
		IT supports for communication with people outside the organization	0.66		
Ambidexterity	**Exploration**	Product problem areas with which customer were dissatisfied were corrected	0.87	33.55	0.83
		Problem areas with which customer were dissatisfied were covered	0.85		
		New knowledge, methods and inventions were introduced	0.75		
		Many new novel and useful ideas were produced	0.74		
	Exploitation	The team was able to identify valuable knowledge elements, connect and combine them.	0.80	28.92	0.73
		It made use of existing competences related to products/services that are currently being offered.	0.76		
		It was integrated new and existing ways of	0.70		

		doing things without stifling their efficiency .			
		Lessons learned in other areas of the organization were put in operation	0.67		
Performance	**Teamwork**	The team used all product development resources rationally	0.79	61.82	0.89
		The team implemented decisions effectively	0.84		
		The team used product engineering hours efficiently	0.84		
		The team coordinated activities well	0.81		
		The team used financial resources sensibly	0.68		
		The team worked well together	0.75		
		The team was productive	0.78		

* Principal components

Table 4. Descriptive Statistics and Correlations

	Mean	S.D.	Ambidexterity	Convergent*Divergent IT	Teamwork	Market Performance
Ambidexterity	8.73	4.49	1.00			
IT	9.70	4.59	**0.41****	1.00		
Teamwork	2.68	1.00	**0.41****	**0.23***	1.00	
Market Performance	4.04	0.77	**0.26***	**0.20***	0.34	1.00

**p<0.01, *p<0.05

Ambidexterity is the product of exploration and exploitation

Table 5. Results of Regression Analysis

Variable	Model 1: Dependent Variable, Teamwork	Model 2: Dependent Variable, Market performance	Model 3: Dependent Variable, Ambidexterity	Model 4: Dependent Variable, Teamwork	Model 5: Dependent Variable, Market performance	Model 6: Dependent Variable, Teamwork	Model 7: Dependent Variable, Market performance
Ambidexterity	0.41**	0.26*				0.38**	0.21+
IT			0.41**	0.23*	0.2+	0.07	0.11
R^2	0.17	0.07	0.17	0.05	0.04	0.17	0.07
Adjusted R^2	0.15	0.05	0.16	0.04	0.03	0.15	0.05
ANOVA F	14.82**	5.23*	15.6**	4.09*	3.07+	7.50**	3.07*

**p<0.01; *p<0.05; +p<0.1

All regressions include a constant. Beta coefficient displayed

Ambidexterity is the product of exploration and exploitation

Table 6. Results of Cluster Analysis of Ambidexterity Activities (K-means)

	Lowly ambidextrous Product development	**Exploitation-based product development**	**Highly ambidextrous Product development**	**TOTAL**
Exploration	2.79 (0.6)	1.66 (0.7)	4.13 (0.6)	2.80 (1.0)
Exploitation	2.52 (0.7)	3.88 (0.8)	3.84 (0.7)	3.02 (1.0)
N	46	17	15	78

In brackets standard deviation

Table 7. ANOVA Results for Effects of Exploration/Exploitation Configuration on Firm Performance (Teamwork)

CLUSTERS	**Teamwork**
Lowly ambidextrous product development	2.62 (0.92)
Exploitation-based product development	2.98 (1.16)
Highly ambidextrous product development	3.37 (0.85)
Total	2.84 (1.00)
F (Signif.)	3.66*

In brackets standard deviation
*p<0.05.

Table 8. Results of Cluster Analysis of Information Technology (K-means)

	Balance IT configuration	Convergent-based IT configuration	Divergent-based IT configuration	TOTAL
Convergent	3.61 (0.63)	3.62 (0.42)	1.90 (0.61)	3.07 (1.0)
Divergent	3.57 (0.68)	1.36 (0.64)	3.09 (0.77)	3.14 (1.0)
N	44	10	24	78

In brackets standard deviation

Table 9. ANOVA Results for Effects of Information Technology on Firm Performance (Teamwork)

CLUSTERS	Teamwork
Balance IT configuration	3.15 (0.83)
Convergent-based IT configuration	2.02 (1.34)
Divergent-based IT configuration	2.62 (0.91)
Total	2.84 (1.00)
F (Signif.)	6.96*

In brackets standard deviation
*$p<0.05$; +$p<0.1$

Depósito Legal: M-20073 I.S.S.N.: 1579-4873