

New Product Development Process and its Impact on Product Quality

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Abstract

In today's global market, enterprises are faced with intensive competition and, in order to obtain a sustainable competitive advantage, they have to adopt new processes and systems for the development of their new, as well as the improvement of the existing, products. This research proposes a new model that incorporates many factors that are found to positively influence the new product development (NPD) process. Many other important parameters, which negatively affect the application of a new product development model, are also discussed.

The research sample consists of 230 Greek firms. Data analysis includes the use of some statistical methods such as factor analysis, correlation analysis and reliability analysis.

Although some of the results contradict some of the previous findings (for example the relationships between management involvement and the new product development roadmap that is used is not confirmed), it is found that culture, strategy and the ability of the personnel affect not only the "NPD roadmap" but also the quality of the new product development process.

Keywords: New Product Development process, Strategy, Product Quality.

Introduction

All enterprises are established, operate and compete in a continuously expanding and dynamic environment. The technological evolution, the highly competitive environment and the varying (diversified) customer needs, have forced enterprises to search for and apply new product development processes that could improve their products' unique characteristics and quality (Gupta et al., 1986, Edgett, 1996).

Each enterprise adopts its own standards and different approaches to design new product development processes (NPD), depending on its size, type and number of products or services that it produces, as well as its business environment. Consequently, some enterprises focus their attention on the improvement of their product quality, others focus on the improvement of the product's technical specifications, while others look for new product development processes that could reduce the development time and accelerate the production process (Balbontin et al., 2000). According to Tacheuchi and Nonaka (1989), Wheelwright and Clark (1992) and Prasad (1996), in the last few decades the rules of the new product development "game" have dramatically changed. Enterprises have realised that high quality, low cost and differentiation strategies are not enough to lead them to business success (Kaplan and Norton 2001). According to Pooltan and Barclay (1998), innovation should be focused on customers, while its success depends on how much innovation conceptualises consumers' needs and requirements.

The aims of this study are:

- 1 The description of NPD processes, which constitute one of the basic success components for an enterprise.
- 2 The determination of the NPD methods that have occasionally been used from Greek enterprises.
- 3 The examination of the NPD practices and their importance for an enterprise.

Summarising, this study examines the need for establishing new product development processes and investigates whether the adoption of such processes enhances enterprise's competitive advantage. In particular, specific factors affecting an enterprise's goals are examined and a new model concerning the factors affecting the NPD process is presented.

Literature review

According to Bowen et al. (1994), new product development is a fundamental process for an enterprise and constitutes a basic source for revitalising and improving firm's competitive advantage. NPD is a dynamic process, which requires the combination and exploitation of all the enterprise capabilities, in order for a new product with unique characteristics which will satisfy market needs to be produced (Marsh and Stock, 2003).

In 1994, Mercer Management Consulting in collaboration with the R&D magazine, gathered data from 193 enterprises and found that there are some relationships between a) NPD practices and NPD process performance, and b) product life cycle and firm's revenues.

Examining the factors that compose the new product development models.

NPD process success is influenced by certain factors. According to various researchers (Zirger and Madique, 1990; Cooper and Kleinschmidt, 1995; Balbontin et al., 2000), these factors include:

The new product development (NPD) "Roadmap".

New product development is a complex, hard and time-consuming process, which conceals many dangers. An enterprise has to develop a business plan, which is usually called "NPD Roadmap", in order to avoid the development of unsuccessful products, but also to reduce the cost of the development process. This "roadmap" is a tool that can help enterprises to develop new or upgrade existing products, using a process that consists of a number of well-defined logical steps (Nicolas and Ledwitch, 2006). These steps start from the birth of a new idea and are completed with the introduction of a product in the market. This "roadmap" must also determine the duration of the process (Balbontin et al. 2000), the resources that are required for the new product development (Wilkinson and Young, 2002) and the aims (Slevin and Pinto, 1986) that must be achieved at the end of this NPD process (Nicolas and Ledwitch, 2006).

Importance of firm's strategy.

Organisational strategy should be able to monitor and control all the important parameters that affect the efficient operation of the organisational functions. An effective implementation of an organisational strategy can help enterprises to deal with very difficult and highly complicated situations (Koufteros et al., 2002).

H1: Strategy positively affects "NPD roadmap".

The required personnel skills for an effective NPD process.

Everyone who is involved in the NPD process should possess different skills, depending on his/her job requirements and responsibilities. According to Song and Parry (1993) and Song et al. (1997), particular skills for each step of the NPD process are required, in order for this process to be effective. Personnel skills and capabilities that are critical for a project management ("NPD Roadmap") are divided into technical, managerial, and administrative skills (Souder 1987, Song et al., 1997).

H2: Personnel skills positively affect "NPD Roadmap".

Management involvement in the NPD process.

Management involvement and its support for an NPD process is crucial for the successful implementation of this process. Managers must support the development of a new product and also be capable of creating an environment that will enhance personnel confidence and collaboration within this process (Lee et al., 2000). It has been observed that when employees have a high level of respect for their supervisors they work more efficiently. Further, managers who understand the efforts and personal needs of their employees have an advantage in retaining the best employees (Mahaffey, 1999).

H3: Management involvement positively affects "NPD Roadmap".

Organisational Culture.

Organisational culture of an enterprise refers to:

- the adoption of teamwork approach,
- the type of leadership , and

- the implementation of methods that support the creation of new ideas and the transfer of knowledge.

When employees, who are involved in an NPD process, work as a cross-functional or multidisciplinary team, they enhance the possibility of improving the collaboration and communication within the enterprise. However, in order to effectively cope with various business challenges, they must work in a well-designed job environment that would allow them to feel confident, safe and indispensable.

Every enterprise, depending on its culture, applies a unique type of leadership. There are three main types of leadership, the democratic, the authoritarian and the delegatory type (Balbontin et al., 2000).

The participation of all the organisational (hierarchical) levels in the decision-making process is an organisational feature that is very important for a successful NPD process implementation (Lee et al., 2000), which also supports organisational strategic planning.

H4: Organizational Culture positively affects "NPD Roadmap".

The importance of the NPD process for improving product quality.

Product quality refers to the ability of an enterprise to design and produce products that meet consumers' expectations (Hall et al., 1991; Doll and Vonderempse, 1991). The quality of a new product can be achieved by using quality "networks". A quality "network" is constituted by employees who are involved in the new product development process, and whose responsibility is to try to improve a product's quality doing their job in the best way possible.

H5: "NPD Roadmap" positively affects product quality.

Research model

The research model (Figure 1) presents the factors that affect the NPD process and are examined in this study. Specifically, these factors are the implemented business strategy, the skills of the personnel, the management involvement in the NPD process, and the organisational culture. Additionally, "NPD roadmap" and product quality are also included in the model as dependent factors. The reason why these particular factors are included, but also the way they are measured, has been described in the literature review section. A short summary of the literature supporting this model is also presented in Table 1.

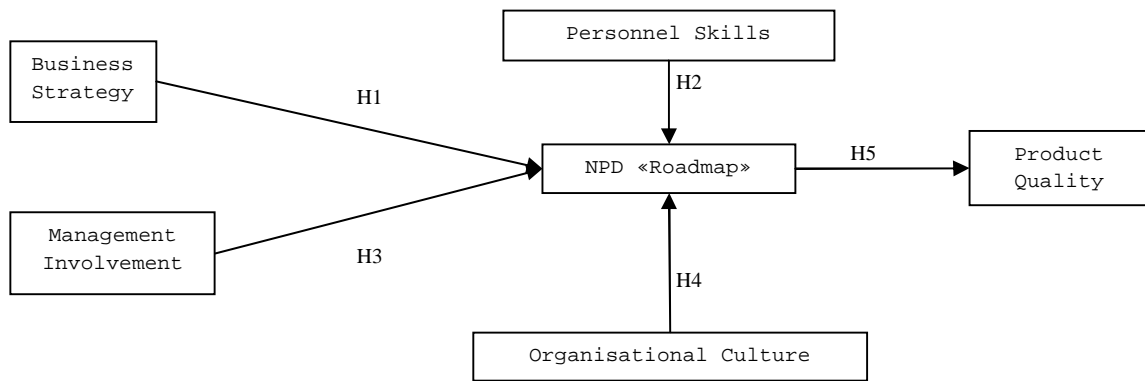


Figure 1: New product development model.

Table 1: Research model factors and previous researches

| | Factors | Items* | Supporting literature |
|---|---|--------|--|
| 1 | Business Strategy | 5 (5) | Booz et al. (1982,)Cormican & O' Sullivan (2004) |
| 2 | Personnel Skills | 5 (4) | Song & Parry, (1993) |
| 3 | Management Involvement | 6 (3) | Smith & Reinertsen (1991),Lee et al. (2000) |
| 4 | Organisational Culture | 10 (8) | Souder, (1987), Brown & Eisenhardt (1995) |
| 5 | Applied NPD Process** | 6 (2) | Page (1993), Dooley et al., (2004) |
| 6 | NPD Process Duration** | 10 (3) | Page,(1993), Balbontin et al., (2000). |
| 7 | Essential NPD Resources** | 3 (2) | Cormican & O' Sullivan (2004) |
| 8 | Level of NPD Process Goal Achievement** | 10 (7) | Kleinschmidt (1994), Balbontin et al., (2000), Terziovski (2002) |
| 9 | Product Quality | 12 (4) | Doll & Vonderempse (1991), Cooper & Kleinschmidt (1996) |

* In parenthesis is the number of items remaining in the final model (after using Factor analysis).

** NPD "roadmap" is measured using these four different factors.

Research methodology

A structured questionnaire was sent to managers of Greek manufacturing industries, mainly located in Athens, Thessalonica, Lamia and Xanthi. Initially, the appropriate person within each firm was contacted and then questionnaires were either sent to them (email, fax, post) or given to them during a pre-arranged meeting. Totally, 350 enterprises had been selected and accepted to participate in the research, however only 230 (66%) of them have, finally, responded. Those who finally answered the questionnaire are: CEOs (26%), managers (32,9%), directors (9,6%) and line managers (31,5%). The average previous job-experience of all participants is 11 years.

Data analysis and results

Descriptive Statistics

The participated enterprises employ, on average, 175 administrative employees and 97 production-employees. A large proportion of the participating firms are "leaders" (21,9%) or "big players" (35,6%), while 20,5% of them are considered as "competitive" enterprises or "small players" (20,5%). Only 1,4% of them think of themselves as "followers".

As far as business strategy is concerned, Greek enterprises implement specific strategy patterns (mean score 3,83), which are also very flexible (mean score 3,71). Further, it seems that Greek enterprises "hesitate" to use a new or improved NPD process (mean score 3,00), but they utilise sufficiently their resources in order to develop new products (average duration of NPD process is 2 years). Table 2 presents the descriptive statistics of the sample as far as the main factors/items examined.

Further, it is also extracted that the personnel work in groups (mean score 4,23), while an another interesting result is that enterprises exploit technology (email use - mean score 4,42; databases use - mean score 3,76; supply management systems use - mean score 3,67). As far as organisational culture is concerned, Greek enterprises support team working but they are not "generous" in offering employee rewards.

Factor and reliability analysis

Confirmatory factor analysis (with Varimax Rotation) has been performed to examine whether the initial classification of the variables into the specific factors is valid or not (Table 3). KMO (Kaiser-Mayer-Oltin) is used to measure the sampling adequacy, accepting a weak threshold (0.5) (Malhotra, 1999). The total variance explained (TVE) score is also used to measure how data is distributed within a range, and how much the responses differ (accepted threshold 0.6).

Further, Cronbach's alpha (α) reliability test has also been performed to assess internal consistency of measurements, adopting the weak threshold 0.6 (Nunnally, 1978, De Vellis, 1991, Carmines and Zeller, 1979). This analysis indicated that: 1) management involvement, 2) NPD process and 3) essential NPD resources, have statistically weak reliability (low Cronbach α scores). These results possibly occurred because of the size and the weak homogeneity of the sample. Conclusively, factor analysis indicated that the items measured can support the proposed research model.

Table 2: Descriptive statistics of the measured items

| Factors | Items | Mean* | Standard deviation |
|-------------------|---|-------|--------------------|
| BUSINESS STRATEGY | Implementation of a specific strategy for its new product activities | 3,83 | 1,05 |
| | Degree of flexibility of the applied strategy | 3,71 | 1,08 |
| | Degree of well-defined action fields in your NPD process | 3,57 | 0,91 |
| | Degree of well-defined goals to all the personnel, that the company wants to achieve by the NPD process | 3,46 | 1,05 |

| | | | |
|---------------------------------------|---|--------|------|
| | Degree of efforts for NPD during the period 2003-2006 | 2,68 | 1,55 |
| PERSONNEL SKILLS | Sufficiency of participating skills and team actions of the leader | 3,78 | 0,98 |
| | Sufficiency of the leader to enforce his authority to the personnel | 3,67 | 0,82 |
| | Degree of team work of production personnel | 4,23 | 0,73 |
| | Level of team members that are qualified for all tasks | 3,67 | 1,09 |
| MANAGEMENT INVOLVEMENT | Use of the democratic model of leadership | 1,36** | 0,48 |
| | Use of the authoritarian model of leadership | 1,70** | 0,46 |
| | Use of the delegatory model of leadership | 1,88** | 0,33 |
| ORGANISATIONAL CULTURE | Rewards with gifts provision (e.g. travel, car) | 1,78 | 0,41 |
| | Rewards with free supper provision with the most effective employees | 1,93 | 0,25 |
| | Rewards with cash bonus | 1,82 | 0,38 |
| | Rewards with promotion | 1,84 | 0,37 |
| | Degree of using cross-function teams | 3,06 | 1,18 |
| | Level that is believed that cross-functional teams are important in developing new products | 3,74 | 1,03 |
| | Degree of personnel teamworking | 3,78 | 0,98 |
| APPLIED NPD PROCESS | Level of team members that are qualified for all tasks | 3,67 | 0,82 |
| | Degree of application of a new or considerably improved NPD | 3,00 | 0,99 |
| NPD PROCESS DURATION | NPD process that is applied | 2,83 | 0,84 |
| | NPD duration (In years) | 1,67 | 1,24 |
| | Time of completion of finances analysis (In months) | 1,44 | 2,09 |
| ESSENTIAL NPD RECOURSES | Time of completion of a promotion process (In months) | 4,45 | 6,62 |
| | Degree of overrun cost according to the programmed cost for the new product production | 2,00 | 0,91 |
| LEVEL OF NPD PROCESS GOAL ACHIEVEMENT | Degree of overrun time according to the programmed time for the new product production | 2,01 | 0,84 |
| | Percentage of ideas that come to the step of process development | 83% | 0,71 |
| | Percentage of ideas that come to the step of construction | 67% | 0,30 |
| | Percentage of ideas that come to the step of test and validation | 54% | 0,28 |
| | Percentage of ideas that come to the step of promotion | 52% | 0,27 |
| | Percentage of ideas that come to the step of design | 56% | 0,31 |
| | Percentage of ideas that come to the step of the idea development | 61% | 0,30 |
| PRODUCT QUALITY | Percentage of ideas that come to the step of the best idea selection | 55% | 0,34 |
| | Degree of reliability as a quality factor | 4,60 | 0,66 |
| | Degree of performance of a product as a quality factor | 4,64 | 0,65 |
| | Longer product life cycle as a quality factor | 4,01 | 1,11 |
| | Degree of correspondence to the needs of consumer as a quality factor | 4,31 | 0,92 |

Only items included in the final model are presented.

*(1 = Not at all - "Negative" ... 5 = Too much - "Positive"), (** 1=Yes, 2=No).

Table 3: Factor analysis

| Factors | Statistics | Items | Loadings |
|------------------------|--|---|----------|
| BUSINESS STRATEGY | K.M.O.= 0.762 Sig = 0,00 (TVE) = 52,047 Cronbach (a) = 0.768 | Implementation of a specific strategy for its new product activities | 0,846 |
| | | Degree of flexibility of the applied strategy | 0,766 |
| | | Degree of well-defined action fields in your NPD process | 0,766 |
| | | Degree of well-defined goals to all the personnel, that the company wants to achieve by the NPD process | 0,634 |
| | | Degree of efforts for NPD during the period 2003-2006 | 0,559 |
| PERSONNEL SKILLS | K.M.O.= 0.500 Sig = 0,00 (TVE) = 71,204 Cronbach (a) =0,564 | Sufficiency of participating skills and team actions of the leader | 0,844 |
| | | Sufficiency of the leader to enforce his authority to the personnel | 0,844 |
| | K.M.O.= 0.500 Sig = 0,00 (TVE) = 73,262 Cronbach (a) =0,628 | Degree of team work of production personnel | 0,856 |
| | | Level of team members that are qualified for all tasks | 0,856 |
| ORGANISATIONAL CULTURE | K.M.O.= 0,605 Sig = 0,00 (TVE) = 64,773 Cronbach (a) = 0.628 | Rewards with gifts provision (e.g. travel, car) | 0,751 |
| | | Rewards with free supper provision with the most effective employees | 0,806 |
| | | Rewards with cash bonus | 0,585 |

| | | | |
|---------------------------------------|---|---|-------|
| | K.M.O.= 0,605 Sig = 0,00 (TVE) = 64,773 Cronbach (a) = 0,753 | Rewards with promotion | 0,643 |
| | | Degree of using cross-function teams | 0,852 |
| | | Level that is believed that cross-functional teams are important in developing new products | 0,899 |
| | | Degree of personnel teamworking | 0,864 |
| APPLIED NPD PROCESS | K.M.O.= 0,605 Sig = 0,00 (TVE) = 64,773 Cronbach (a) = 0,642 | Level of team members that are qualified for all tasks | 0,822 |
| | | Degree of application of a new or considerably improved NPD process | 0,734 |
| APPLIED NPD PROCESS | K.M.O.= 0,500 Sig = 0,00 (TVE) = 53,884 Cronbach (a) = 0,140 | NPD process that is applied | 0,734 |
| | | NPD duration (In years) | 0,857 |
| NPD DURATION | K.M.O.= 0,692 Sig = 0,00 (TVE) = 69,173 Cronbach (a) = 0,695 | Time of completion of finances analysis (In months) | 0,800 |
| | | Time of completion of a promotion process (In months) | 0,837 |
| | | Degree of overrun cost according to the programmed cost for the new product production | 0,873 |
| ESSENTIAL NPD RESOURCES | K.M.O.= 0,500 Sig = 0,00 (TVE) = 76,265 Cronbach (a) = 0,140 | Degree of overrun time according to the programmed time for the new product production | 0,873 |
| | | Percentage of ideas that come to the step of process development | 0,851 |
| LEVEL OF NPD PROCESS GOAL ACHIEVEMENT | K.M.O.= 0,809 Sig = 0,00 (TVE) = 75,284 Cronbach (a) = 0,8908 | Percentage of ideas that come to the step of construction | 0,924 |
| | | Percentage of ideas that come to the step of test and validation | 0,840 |
| | | Percentage of ideas that come to the step of promotion | 0,923 |
| | | Percentage of ideas that come to the step of design | 0,820 |
| | | Percentage of ideas that come to the step of the idea development | 0,853 |
| | | Percentage of ideas that come to the step of the best idea selection | 0,800 |
| | K.M.O.= 0,707 Sig = 0,00 (TVE) = 74,502 Cronbach (a) = 0,828 | Percentage of ideas that come to the step of design | 0,893 |
| | | Percentage of ideas that come to the step of idea development | 0,850 |
| | | Percentage of ideas that come to the step of the best idea selection | 0,846 |
| | K.M.O.= 0,810 Sig = 0,00 (TVE) = 84,993 Cronbach (a) = 0,940 | Percentage of ideas that come to the step of the process development | 0,923 |
| | | Percentage of ideas that come to the step of construction | 0,965 |
| | | Percentage of ideas that come to the step of test and validation | 0,917 |
| | | Percentage of ideas that come to the step of promotion | 0,881 |
| PRODUCT QUALITY | K.M.O.= 0,560 Sig = 0,00 (TVE) = 75,793 Cronbach (a) = 0,670 | Degree of reliability as factor of quality | 0,880 |
| | | Degree of performance of a product as factor of quality | 0,845 |
| | K.M.O.= 0,560 Sig = 0,00 (TVE) = 75,793 Cronbach (a) = 0,655 | Longer life cycle of a product as factor of quality | 0,847 |
| | | Degree of correspondence in the needs of consumer as factor of quality | 0,879 |

Correlation analysis

The results of the correlation analysis (Table 4) show that there are many statistically significant relationships between the factors included in the model (significance level <0,05 or <0,01). Thus, looking at Table 4, it is realised that many hypotheses of the research model (Figure 1) have been confirmed, while some new correlations between these factors have also been extracted.

More specifically, a strong positive correlation ($r=0,435$) between the level of NPD process goal achievement and the personnel skills appeared, possibly indicating that the level of NPD process goal achievement is affected by the skills of the personnel who have the responsibility for completing the NPD process. This result only partly confirms the second hypothesis, since personnel skills affect only the level of NPD process goal achievement and not the other three "NPD Roadmap" factors.

Moreover, it can be noticed that the NPD process is related to: i) the business strategy ($r=0,353$) and ii) the organisational culture ($r=0,231$). These results confirm hypotheses H1 and H4, which concern the factors affecting the new product development process. Hypothesis 3, which concerns the relationship between management involvement and new product development, is not confirmed ($r=0,139$). This perhaps indicates that management involvement is

weak when the organisational strategic planning is clear and the organisational environment “encourages” and supports NPD processes.

Table 4: Correlation analysis

| | | Business Strategy | Personnel Skills | Management Involvement | Organizational Culture | NPD duration | Level of NPD process goal achievement | Applied NPD process | Essential NPD recourses |
|-------------------------------|-----------|-------------------|------------------|------------------------|------------------------|-----------------|---------------------------------------|---------------------|-------------------------|
| Personnel Skills | r sig. | ,171 ,150 | 1 | | | | | | |
| Management | r sig. | | | 1 | | | | | |
| Organisational | r sig. | ,250(*) ,034 | ,383(**) ,001 | | 1 | | | | |
| NPD Duration | r sig. | | | | | 1 | | | |
| Level Of NPD Goal Achievement | r sig. | ,240 ,120 | ,435(**) ,004 | | ,224 ,148 | | 1 | | |
| Applied NPD Process | r sig. | ,353(**) ,002 | | | ,231 ,051 | | | 1 | |
| Essential NPD | r sig. | | | | | ,326(*) ,015 | | | 1 |
| NPD “Roadmap” | r sig. | ,264 ,087 | | | ,921(**) ,000 | | ,339(*) ,026 | ,536(**) ,000 | |
| Product Quality | r sig. | ,329(**) ,004 | ,387(**) ,001 | | | | ,405(**) ,007 | ,308(**) ,009 | |

*Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Moreover, it is noticed that product quality is related with the level of NPD process goal achievement that the enterprise wishes to achieve (r=0,405) and the applied NPD process (r=0,308), but it is not related to the “NPD roadmap” as a whole. So, hypothesis 5 is only partly confirmed.

Furthermore, organisational culture is related with the implemented organisational strategy (r=0,250). A relationship also exists between culture and personnel skills (r=0,383), underlining the important role of organisational culture in the successful implementation of a new product development process.

Product Quality is related to the organisational strategy (r=0,329) as well as to personnel skills (r=0,387). These relationships imply that an efficient organisational strategy has to be supported by capable and efficient personnel, in order for premium products to be developed.

Concluding, the development of new products is associated with the selected NPD process ($r=0,339$), the NPD process duration ($r=0,921$) and the volume of the essential NPD resources ($r=0,536$).

Conclusions

The results of the statistical analysis have shown that "NPD Roadmap" is mainly related to the business strategy and the organisational culture and partly to personnel skills. An interesting conclusion is that management involvement does not have a statistically significant positive effect on "NPD Roadmap". This finding indicates that a combination of personnel skills, business strategy and organisational culture support the NPD process. As far as the outcome of this process (product quality) is concerned, it is found that not only business strategy, personnel skills and well defined goals but, also, the actual NPD process adopted and implemented, significantly affect the quality of the products produced.

However, the mix of the factors that determines the success of an organisational innovative attempt may vary, depending on the unique importance of each factor for an enterprise. This occurs because enterprises have to be very flexible in order to sustain their competitive advantage and to survive in a dynamic market environment. As a product manager said: "We are running as fast as we can to keep up with or just keep ahead" (Terziovski et al., 2002).

Managerial implications

From a managerial perspective, it can be concluded that if all the steps of the NPD process are not followed, then the new product will not meet the targeted quality standards, neither will it meet customers' expectations and needs and, thus, it will not be profitable. Additionally, a very important conclusion that comes from hypothesis 3, is that managers may increase their influence to the product development process by utilising the organisational culture, the personnel skills and abilities and, also, by setting clear organisational goals.

Limitations

The first limitation of this research has to do with the sample size that is considered as relatively small (230 firms). Another concern is that the research sample includes heterogeneous enterprises from various sectors. Therefore, a similar study could possibly be applied to a bigger and more representative sample. Further, this study is based on a specific new product development model that could be expanded to include other important parameters as well. Finally, the direction of the causality for the new relationships of the model should be further examined.

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