

Proposal of a Systemic and Integrated Framework to Support New Product Development Design

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Abstract

New product development (NPD) is crucial for the existence of firms, as a source of competitive advantage and a determinant factor of business success. Several factors, both operational and corporate or even strategic, contribute to the process of innovation that supports the NPD. The holistic assessment of all these factors, taken together, has not been subject of research leading to the proposal of an integrated and systemic framework. Thus, this paper aims to propose a comprehensive framework, which integrates the strategic, organizational and procedural levels, as well as the set of factors to take into account in NPD projects problems to be solved with innovative solutions. Based on literature review, a comprehensive and integrated conceptual framework is obtained through a deductive-inductive pathway. The framework was referred as “Systemic and Integrated Framework of NPD” - SIFNPD.

Keywords

Innovation, New product development, Framework, SIFNPD, Innovative solutions

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1. Introduction

Innovative and creative processes are the origin of new products that companies approach in a systematic way. NPD processes are crucial for the competitiveness of firms, being one of the most determinant factors of business success in the global market. For that, the ideas about new products must be implemented by firms and brought to market as quickly as possible, in order to get advance over the competition in a market that nowadays is very dynamic and unpredictable. But the innovation that supports NPD is a difficult path to travel, and the failure of an idea or a project that initially seem destined for success, can possibly be destined to fail. So, the NPD involves risks to have in account associated to the current characteristics of the markets. Thus, firms must be aware of risks to transpose to gain prominence in the market. As a result of these difficulties, the time available to manage efficiently and effectively in NPD design is becoming shorter, as well as the life cycle of the products. Under these conditions, is crucial to firms sharing innovation through networks, but for share can be possible, it is necessary that managers have a holistic view of the value chain, in particular with regard to the parameters and variables to take into account it all levels of strategic, organizational and procedural approaches. This finding is crucial in NPD projects and their implementation that requires an increasingly rational and comprehensive approach. The literature revision that supports this paper revealed a lack of a systemic conceptual and functional framework encompassing the various conceptual levels: strategic, organizational and operational, to take into account in NPD projects. To serve these needs is proposed in this paper one Systemic and Integrated Framework of NPD (SIFNPD). This framework revealed to be very embracing concerning the value chain in which the firm is integrated. Therefore it was shown to have a potential application in industry in the near future.

2. The Surroundings of a NPD Process

In order to build a theoretical framework, that is systemic and integrated, a number of several factors that determine the NPD had to be considered. In particular, it was necessary to realize those who were involved to the strategic environment of a NPD process. To this end it was necessary to analyze the parameters and variables that comprise NPD strategic environment and arrange them by levels in a hierarchical way. Such levels were detected as following: a first systemic and strategic level, which is the most embracing of all, because integrates the value chain main aspects that are connected to a NPD process; then a second organizational level that decomposes into two sub-levels of equal importance - the corporate culture and the management principles of a firm - both responding to market situations; and finally, a third operational or procedural level, which is the most particular one, because it concerns to specific parameters and variables inherent to the firm itself. These three levels are connected in a systemic way, which means that they interact with each other always and in all directions - not only in an up/down way - that also allowed a totally dynamic approach of the framework.

2.1 Systemic and Strategic Environment Level

This level embraces the aspects concerning the market that surrounds firms that develop NPD processes. At this first level is fundamental the existence of an intimate relationship between innovation, which is the source of NPD, and strategy [1]. Strategic innovation embodiments in



a highly competitive environment are a key factor to the survival of firms that develop new products. The works of [2] and [3] showed the existence of industries based on products usually of disruptive nature that develop in an environment without competitors they called "blue ocean strategy" (BOS) as opposed to the conventional market of high level of competition that they designated by "red ocean strategy" (ROS). According to the same authors, BOS products are pioneers in the market, given the absence of competitors. Indeed, according to these authors a red ocean represents all industries that currently exist - the known market space, and a blue ocean demarcates all industries that do not yet exist - an unknown space. About these two opposing strategies [2], reported that at ROS, the boundaries of industries are defined and accepted, and the business aspects are known to all competitors. Here, firms try to overcome their rivals in order to gain more and more market share they are competing in. In recent decades the strategic focus of enterprises, according to the authors, has been based in painful and difficult survival in these oceans "red blood spilled in fights and deaths" (bankruptcies). A BOS policy is especially relevant for faster growth of companies and businesses creating unique offerings for new markets rather than compete with existing rivals. Nowadays even innovative leadership can itself be assumed from the strategic standpoint as being a "blue ocean leadership". But there are hybrid strategies in which firms develop new products that emanate from both radical and gradual forms of innovation. Based on experiments conducted in a sample of Italian small and medium enterprises (SMEs) regardless of the strategic policy options, firms have to make other decisions involving more factors of systemic and strategic nature and should be considered together thus requiring rigorous evaluations of the trade-offs involved, namely those that study the various risks and their committed relationship [4]. In a competitive environment of greater complexity in production processes there are risks that must be evaluated in a systematic way. This implies an ongoing evaluation of trade-offs combining the various risk factors of NPD and their respective projects, especially those involving quality, time and costs, whether NPD policies are based on radical, incremental or mixed innovation strategies, these firms can not overlook the risks they expose themselves and also need to be attentive to the dynamics of competition by implementing systematic benchmarking practices [5]. In order to achieve the most interesting performances of NPD business, [6] carried out the benchmarking of best practices concerning the most used topics of the highest performing companies in this field, and concluded the importance of factors that relate to the teams that develop new projects, their multidisciplinary and collaborative attitude, which should integrate the corporate culture. The globalization of markets and business operations is a trend that will remain strong in the coming decades, according to [7]. The works developed by these authors showed that an unavoidable aspect of the process of globalization has been the global trend of outsourcing, especially the knowledge-based services, such as NPD. Also, due to the compulsive need for companies to reduce costs in the developed world, the question is not whether a particular company will outsource or work abroad, but when it will outsource and how it will leverage outsourcing for greater competitive advantage. One of the problems that arise in the process of outsourcing, offshoring in particular, is the "intellectual property" (IP) jointly developed. The referred work of [7] also examines the effect of the access, exploitation and defense of IP when generating innovation, both incremental as radical, carried out by firms outsourced and concludes that, in political terms, this situation is nonetheless have implications for the strategic management of the focal company. Globalization and internationalization of business involving NPD projects correspond to engineering and management complex systems, both in the integration of the project as the product itself, which often involve research and subjects highly reserved. According to [8], these strategic options contain risks of opportunistic expropriation of knowledge and related monitoring costs of the subcontracted partners, which sometimes are not only distant in geography but also in culture. This author proposes the modularity of the project, as a technique, which constitutes as a good chance to moderate the relationships complex model, because it can serve as a substitute for other less effective formal or informal controls in a "portfolio controls". Still on the internationalization and globalization of NPD projects [9] present several case studies, diverse and enlightening facing the strategic options for

offshoring and/or onshoring product design for the following phases: development of system architecture; of the tasks and components and the integration of the overall system. These authors concluded that the exclusive skills and responsibilities of the focal firm must ensure control over content, design and interface processes, decisions onshore/offshore, third-party option (third-party logistics 3pl) and above all, ensuring the integrity of the final product. The development of these systems in a network of relationships, involve increased complexity and the concomitant risk that deserve evaluation of their trade-offs. From the point of view of corporate strategy and business in industries NPD, is also considered crucial the ongoing and systematic relationship with the market, meeting and even anticipating, if possible, the needs of customers [10]. Therefore, the marketing performs this important function which is to establish a permanent communication between the company and the market making heard within the organization which is known as the "voice of the customer". The main features that should be noted, since the recognition of the needs of the market through production and final product delivery (areas beyond the domain of NPD), through the design specifications of the product, as well as the various phases of the project, according to [11], are presented next. Firstly the permanent interaction with the customer, providing important suggestions, as well as a validation built step by step with the designer, resulting in the evolution of the product in the form of intermediate functional prototypes. Despite the difficulties, such interaction could prove critical to the success of certain new products for the right kind of customers. Secondly, the consideration that the solution resulted in a relevant experimentation and application to concrete cases of new customized products [11]. Thirdly, the strategy of intimate relationship with the market and customers, in a firm that develops new products, often follows along with fellow close relationship with many suppliers involved in the new projects [12]. According to [13], it must also be considered that in strategic terms, if innovation in NPD requires the marketing function, the role played by it in the development of the project also depends on the level of product innovation in question as well as their design and the positive trade-off marketing/quality cost/time. From a general perspective, obtained from the literature on the most relevant factors that comprise a systemic and strategic vision in NPD environment described above, is presented in Figure 1 with a thereof summary.

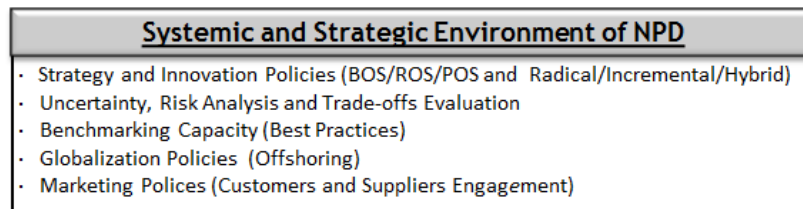


Figure 1 - Systemic and strategic environment of a NPD process

2.2 Organizational Environment Level

This level embraces the aspects concerning the culture and principles of management adopted by firms that develop NPD processes. In the literature review was detected some confusion regarding the aspects involving firm's management, thus, came the need to find a way to present the information in a most organized way. So, it was assumed that: parameters influencing in a structural way firms that develop new products, report to corporate culture; and the ones of a conjunctural order derivate from management and their managerial principles. Each one has specific factors, as evidenced by the existing literature, and that will be explained in the next two sub-chapters.

2.2.1 Corporate Culture

One of the most relevant organizational parameter that can be considered part of a corporate culture is the ability to function in the development of projects with cross-functional teams perfectly interlocked in a natural and systematic way. [14] advise a multidisciplinary, multifunctional and/or cross-functional organization type. [15], propose the formation of collaborative teams (e.g.), which may include employees of the organization, suppliers and customers. Therefore, it is crucial reliable information flow, which ensures visibility and transparency in connecting people, processes and technologies. Through information obtained from the presented quotes it's realized that the organizational strategy of working in multidisciplinary integrated teams (cross-functional) is not an isolated reality but who live together in partnerships and collaborative alliances with inter-organizational information sharing, skills and innovation. That is, a joint innovation capacity and development of products and projects in organizations that work on network and that encompass collaboration with customers and suppliers [16]. Another way to characterize the innovative processes is what concerns to open innovation and, in contrast to that of the stems, fewer recurrent insulation business. Open innovation phenomena are commonly known as the knowledge of transfer in which resources move easily at the border or interface company/market [17]. When open innovation is necessarily shared in the form of partnership or strategic alliance assumes the designation of co-innovation [18]. These authors also found that through this shared innovation, can benefit the value chain to the customer, this sorting model of win-win, thus enhancing the new product from the market. About this theme [19], argue that the co-innovation represents a new paradigm of innovation where new ideas and approaches from different internal and external sources are integrated into a platform in order to generate new organizational and values shared network. Yet according to the authors, the core of co-innovation includes engagement, co-creation and the great experience of value creation. So, the benefits of sharing innovation and on the collaborative and cooperative processes operating on the network are key factors to the survival of firms. It was concluded that the set sharing various factors such as: ability to network with collaborative alliances and processes of open innovation; co-innovation; co-design and joint development, should work seamlessly to achieve a better performance in NPD [20]. According to these authors it follows that the corporate culture should incorporate another common inter-organizational factor: the competitiveness. It regarding to install in the institution, in a lasting way, a competitive spirit associated with the effectiveness and success of new products available to the market.

2.2.2 Management Principles

On the principles of management, organizational parameters as response to the market situation, are considered the following relevant factors: compliance with legislation of the product inherent to each of the specific markets in which each product or all of them are developed, produced and consumed; product standardization that permits conform with international rules and internal flexibility, facilitating the process of modularization; certification; and the association and the agility and performance, which also connects to philosophy or lean thinking in the search for maximum efficiency and productivity [21]. In order to embody the paradigm of optimal organizational and process productivity there is need to combine lean practices with flexibility and quick response, the manufacture of various types of products and agility to mass production [22]. Since long ago that [23] understood the need to associate lean and agile concepts and even proposed the term "leagility" to integrate them in the paradigm of Supply Chain Management (SCM) in response to markets. Likewise, flexibility combined with the concept of proactive flexibility was transformed into "adaptability". Considering the relevant factors NPD integrated at the organizational level and based on the literature review is presented a summary thereof in Figure 2.

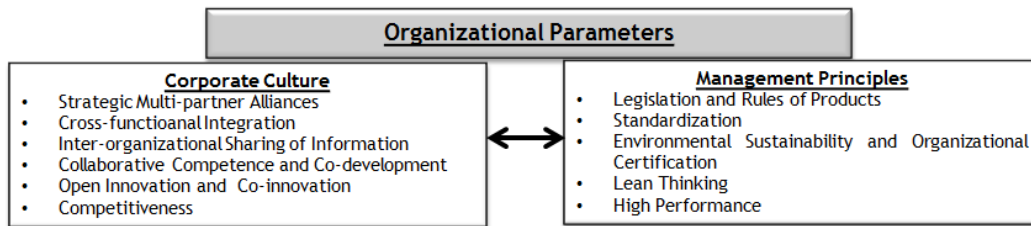


Figure 2 - Organizational parameters involved in a NPD process

2.3 Processual Environment Level

Upon approach to the relevant factors and parameters that integrate the strategic and organizational levels that influence organizations to develop new products with the support of the literature, it is now a third operational level with the procedural variables. There are considered as relevant process variables: the materialization of the idea of the product through a process of innovation management, that concerns to: the organization and management of the project; the quality of the project; the product and its control; the engineering capabilities; as well as the technological [24]. Add up tools and methodologies for problem solving NPD, namely innovative problems. It can be said that innovation management is a structured process of getting new ideas, which enables an organization to realize new ways to create value and anticipate technological and market demands. There are different perspectives of innovation, product, process, etc., so under every point of view, each innovation process is unique [25]. From product point of view, innovation is therefore a process of creation and introduction of something new (different characteristics or features) not yet known by the market or put into practice and that is related to many factors such as research, technology, creativity, invention, etc. Therefore, it is not a one-off measure, but an overall process extending over time. [26] describe innovation as a process of generating ideas that can be convergent or not convergent. Convergent when the idea is the result of a systematic collective process based on trial and error; not convergent when a "flash of genius" of some bright and creative collaborator occurs. To [27] there is a value chain of innovation that consists of three main phases: generation of ideas; conversion which decomposes in the selection of ideas and their development; and finally, its dissemination by the organization and the market. If the decision of the materialization of the innovative idea into a new product is the first step towards its implementation and development, the next step corresponds to the project management of NPD. There are proposals for generic project management that can be considered classic as is the case of the sequential model of [28]. Beyond the architecture of the product, when it takes place on a global scale [9] assume the existence of two types of architecture in the administration of NPD projects. So, they refer to "organizational architecture" that groups, composes and arranges the sub-teams, their inter-relationships and hierarchies, in terms of information flows and the "architecture of processes", which organizes the set of tasks and activities, as well and the respective flow-related information between this set and the sum of which will produce in terms of the final product. [9] also present a model of iterative project management, or other designating the spiral model. In the proposed spiral flexible specifications are possible, thus avoiding the need for resumption of work whenever the complexity oblige. The spiral repeats regular steps, including concept development, level design, details, integration and testing. Either way should be considered variants of the sequential model. But there are other interesting proposals for managing NPD projects more agile and flexible, sufficiently tested in industry and widely disseminated in the scientific world. It's the case of concurrent or simultaneous engineering, and the Stage-Gate® as referred by [29]. The guarantee of the quality levels of the project and the new product is also a relevant variable in the process, as consider by these authors. It is also the current application of Taguchi method and its specific tools in order to obtain sufficiently robust products and high quality, under fluctuations, which may

influence both the environment of the NPD project, as the production process itself [30]. The implementation of NPD also implies control of varying capacities, which stand out as the most relevant: the engineering capabilities and the technological ones [24]. Failing to master all these skills, many firms integrated in open innovation networks, find in technology licensing a cheap and effective way to access external knowledge for NPD [24]. Also in the case of many engineering processes and their installed capacities, the authors point to the participation in collaborative networks as a way to solve many of the needs not met by existing capacity. [31] arrive at the same conclusion for the need for prototyping, where collaboration is established across functional, hierarchical and organizational boundaries. Considering the most relevant variables integrated into the NPD process level, and based on the literature, presents a summary thereof in Figure 3.

Process Variables
<ul style="list-style-type: none"> . Innovation Management (New Product Ideas) . Project Management . Products Quality Assurance . Engeneering and Technologies Available . Problems and Innovative Solutions

Figure 3 - Processual variables involved in a NPD process

3. A Framework for NPD Processual Problems and Innovative Solutions

The tools and methodologies available for innovative problem solving and other NPD problems are one of the most important variables of the respective process and [32] conducted a survey of about three dozen tools and techniques obtained and listed after the literature review and interviews with managers and administrators in a sample based on Taiwanese companies, as well as discussions with experts. Based on this sample is presented in Table 1 more than two dozen tools that are commonly found in literature on NPD.

Table 1- NPD Tools and methodologies

Survey of Tools to Support NPD	
Grouping	Tools and Methodologies
Creative and Innovative Solutions	TRIZ; DOE; DFX; Pugh analysis; Creative Design; Axiomatic Design
Focus on Quality Function	QFD (e.g.: Kano Model; Ishikawa diagram; DFMEA; Pareto law)
Focus on Precision Manufacturing	DFSS (DMAIC cycle and it's variants)
Focus on Involvement of Suppliers	SDI
Design Support	Robust Design; Modular Design; CE
Decision Support	AHP; CBR; DEA; Delphi Panel; Fuzzy logics; Neuronal Networks
<small>Acronyms: TRIZ (<i>Theory of Inventive Problem Solving</i>); DOE (<i>Design of Experiments</i>); DFX (<i>Design for Excellence</i>); QFD (<i>Quality Function Development</i>); DFMEA (<i>Design Failure Model and Effect Analysis</i>); DFSS (<i>Design for Six Sigma</i>); DMAIC (<i>Define-Measure-Analyse-Improve-Control</i>); CE (<i>Concurrent Engineering</i>); AHP (<i>Analytical Hierarchy Process</i>); CBR (<i>Case Based Reasoning</i>); DEA (<i>Data Envelopment Analysis</i>)</small>	

As a matter of ease of grading, tools or methodologies, as they are treated in the literature, they were grouped putting its focus on use in: “Creative and Innovative Solutions”; “Focus on Quality Function”; “Focus on Precision Manufacturing”; “Focus on Involvement of Suppliers”; “Design Support” and “Decision Support”. As for the specific model of using tools to solve problems of NPD, it is necessary to know beforehand if similar problems have had or not too

similar solutions. According to [33], this is likely to be achieved by an adequate portfolio of problems and their solutions, as the methodology called "case-based reasoning" (CBR). Other tools are often used for this task, in particular based on fuzzy logic or neural networks [34]. When there is not any solution previously found is necessary to use any of the available tools and methodologies, according to Table 1. If there are several solutions available via portfolio or via panoply of existing tools, it is necessary to determine a ranking in order to adopt the more convenient solution. One of the methods most commonly used for this task is the Analytical Hierarchy Process (AHP), a tool for decision support within the NPD project. And according to [35] is very useful in screening and ranking of possible alternatives for the decision to be made. This conceptual possibility is represented as shown in Figure 4.

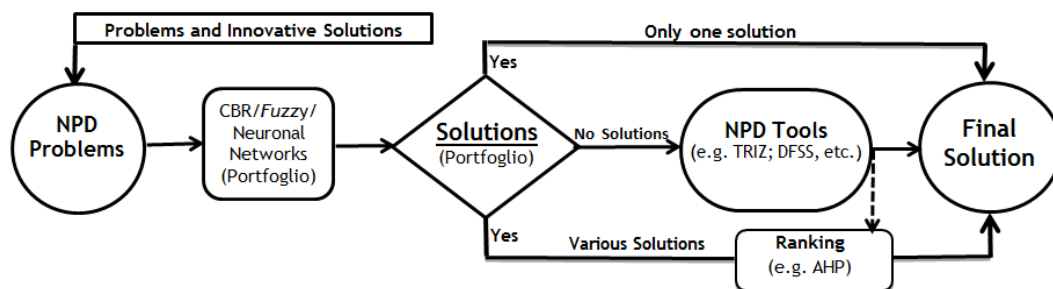


Figure 4 - NPD Problems and Innovative Solutions - Framework Approach

4. Conclusions

The research on literature review was based in a deductive-inductive pathway, and a systemic and integrated conceptual framework (SIFNPD) was achieved. From the literature review was not detect, until now, any holistic frameworks of NPD regarding the NPD phenomenon, but only partial or appropriate for cases of enterprises or industries models. This justified the completion of this investigation, and for all the foregoing, it can be conclude that this objective was achieved. The framework called SIFNPD has in account tree levels of parameters and variables that concerns to NPD processes: 1- systemic and strategic; 2 - firm's cultural aspects and management principles; processual or operational. SIFNPD framework aims to show a way to support the achievement of innovative solutions for NPD process problems during the design phases.

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