

Structuring front-end innovation activities throughout strategic product planning

Thaís Rodrigues^{a*}, Aldo Braghini Junior^a, Antonio Vanderley Herrero Sola^a

^aUniversidade Tecnológica Federal do Paraná, Ponta Grossa, PR, Brazil

*tharodrigues89@gmail.com

Abstract

Strategic product planning (SPP) for new product development (NPD) in the front-end of innovation (FEI) is a great challenge for managers and practitioners. This article analyzes the structuring process of FEI activities during SPP. A research was carried out with 78 industries from both food and furniture in Brazil. Our study revealed that FEI activities are structured in an intricate network with a high level of complexity and interdependence. The large amount of activities and the complexity in structuring them denote that companies are concerned to reduce uncertainties and risks intensifying the planning phase.

Keywords

New product development. Fuzzy front-end. Strategic planning.

How to cite this article: Rodrigues, T., Braghini Junior, A., & Sola, A. V. H. (2017). Structuring front-end innovation activities throughout strategic product planning. *Production*, 27, e20162241. <http://dx.doi.org/10.1590/0103-6513.224116>

1. Introduction

The international competition, the market with sophisticated customers and the technological change have put the NPD in the spotlight (Clark & Fujimoto, 1991). The NPD process the earliest stage, the so-called FEI, has been reported by literature (Cooper, 1988; Koen et al., 2014; Verworn et al., 2008) as critical to determine new product success. This stage has been defined by Cooper (1988) as predevelopment activities of the new product process and encompasses activities in the following groups: the idea generation, the product definition and the project evaluation. Khurana & Rosenthal (1998) have defined the front-end of NPD as a set of activities divided into the following phases: pre-phase zero, phase zero and phase one. Kurkkio et al. (2011) classifies FEI activities into the following stages: the informal start-up, the formal idea-study, the formal pre-study, the formal pre-project. Koen et al. (2014) divide the FEI into the following activities: opportunity identification, opportunity analysis, idea generation, idea selection and concept definition.

From analysis in the innovation process in companies, Cooper (2014) highlights that more emphasis should be done in the front end, becoming it less fuzzy and clearer. This requires a lot of information and consequently activities to be developed in NPD. Front-end planning plays an important role in R&D activities do reduce uncertainties (Song et al., 2007). In this context, structuring FEI activities is a crucial task. According to Markham (2013), FEI should be well-established aiming to reach success.

Literature has studied FEI activities individually, focusing on one or another group of activities. Oliveira & Rozenfeld (2010) proposed a method to support the development of front-end activities based on integrating technology roadmapping and project portfolio management. Chan et al. (2011) proposed a model to integrate product design with market. Schoonmaker et al. (2012) have investigated marketing activities to enable the survival of innovative projects. Heising (2012) proposed an integration of ideation and project portfolio management for NPD success. Teller et al. (2012) investigated the formalization of project portfolio management. Riel et al. (2013) proposed a model for ideation activities in FEI. A work studying a significant set of activities in NPD is lacking in specialized literature.

Although literature has presented several studies on the front-end stage, structuring activities still is a managerial challenge in NPD, as highlighted by Frishammar et al. (2012). The authors Cooper (1988) and Kurkkio et al. (2011) proposes a model with steps in linear sequence with activities being developed in each step. The model proposed by Khurana & Rosenthal (1998) recommends the activities on the pre-phase zero being developed in parallel and the other phases in the series. Koen et al. (2014) have proposed a circular model to develop activities. Besides these concepts, the technical innovation is viewed from an evolutionary perspective. In this direction, Clark (1985) analyzes the sequence of technological changes and argues that the formation of concepts on problem design and market requires a hierarchical structure, due to the nature of the object. According to the author, it is a matter of logic.

In general, models do not present the structure or the sequence of activities in FEI or the relationship among them; therefore, there is a huge gap to exploit this subject. On this issue, important questions are raised: How managers deal with FEI activities during SPP? What sequence are the activities developed in? How do such activities relate to each other? Is there a formalization process? The answers to these questions can help us to understand the relationship among activities as well as to assist managers and practitioners in structuring activities in the front-end. The paper initially presents a theoretical foundation and hypothesis and then it presents a survey conducted with Brazilian industries from both food and furniture. Finally, the paper provides pertinent analysis, discussion and conclusions.

2. Theoretical foundation and hypothesis

Literature has highlighted several activities in NPD (Moeckel, 2009; Rozenfeld et al., 2006; Song & Montoya-Weiss, 1998). A significant literature review is presented in the sequence. In this work, FEI activities are divided into the following groups: strategic scope, market scope and product portfolio scope, as follows.

2.1. Strategic scope

Strategic business plan (SBP) is a way to think the future of the firm's business in a competitive market. Competitive advantage can be created by means of business strategy, which describes how an organization decides to compete in the market in relation to its competitors (Porter, 1987). SBP involves analysis of the environment to build the organization guidelines, determining the strategies and action plans aiming to achieve the goals of the organization. Kahn et al. (2012) have emphasized strategy as the most important dimension, which is associated with the following best practices: goals clearly defined and aligned with the organization mission and strategic plan, long-term view, the regular revision of projects, identification of opportunities to respond to market forces and new technology. Technological and market alignment is positively affected by strategic planning (Acur et al., 2012). A scenario analysis is an important technique to increase the quality and effectiveness of strategic planning in FEI (Postma et al., 2012) and could be used to establish the main possibilities. Based on theory, we state the following hypotheses for the activity A1 (numbers within the parentheses will be used to identify activities in the final model):

A1. Define the scope to review the SBP (1)

H1a. Establish scenarios for market and technologies (15) should be done before.

H1b. Examine the need to revise the strategy (16) should be done before.

H1c. It allows defining the plan – actors, tasks and deadlines (17).

Changes in the market cause uncertainties, increasing the risk of financial return (Mullins & Sutherland, 1998). Regarding continuous changes in institutional and market areas, organizations are compelled to review SBP periodically in order to reduce risks and uncertainties. It is an opportunity to review the mission, goals, strategies and priorities in the strategic plan. Logically, this implies in reviewing the product portfolio. Strategic orientation directly affects the project portfolio structuring, as suggested by Meskendahl (2010). In addition, Marzagão & Carvalho (2014) emphasize that companies need to use feedback on the results of projects in strategic planning.

The external environment requires actions on both sides: market and suppliers. Literature has highlighted the importance to develop a relationship with both customers and suppliers as a source of innovation. Smals & Smits (2012) pointed out that the partnership with supplier is essential to reach long-term competitiveness by means of sustained innovation. Sometimes partnership with more than one supplier could reduce technological,

organizational and commercial uncertainties (Melander & Tell, 2014). Cooper (1988) stated that companies should understand the market in the NPD earliest stage, avoiding product failure. The development of product innovation, according to Cooper & Edgett (2010), requires high effort and encompasses several activities in the following areas: external environment and business. While the first area is focused on the market (opportunities, size and growth rate, competition, technology change, etc.), business is focused on core competencies (personal skills, the production process, resources, etc.). From theory, the hypotheses for the activity A2 are:

A2. Review the SBP periodically (2)

H2a. Define scope of review of the SBP (1) should be done before.

H2b. Suppliers (18) should be consulted before.

H2c. Customers (19) should be consulted before.

H2d. Suppliers and customers (20) should be consulted before.

H2e. Identify constraints of resources, capability and competences (4).

H2f. It allows reducing risks and uncertainties in decision-making (21).

H2g. It allows analyzing the product portfolio subsequently (9).

In order to identify changes in market and technologies, firms need investing in financial resources and time as well as to keep the staff trained. Internal technological capability is a powerful determinant of technology investment effectiveness. Lee & Wong (2011) highlight the importance of improving technology and marketing synergies putting emphasis on learning practices for market and technology assessment, product testing, etc.

Corporate foresight is a strategic management practice to explore the business environment in product innovation (Ruff, 2015). As scenario analysis is an important task to deal with future uncertainties, (Hanafizadeh et al., 2011) the organization could establish political, economic and technological scenario to evaluate commercial areas and design a portfolio for company investment. Firms adopting a long-term view are more likely to initiate planning focused on opportunities and threats (Harris & Ogbonna, 2006). From theoretical foundation, the hypotheses for the activity A3 are:

A3. Identify changes in both market and technologies (3)

H3a. It has to train professionals for both collection and interpretation data (22) before.

H3b. It has to invest in financial resources and time (23) before.

H3c. Suppliers (18) should be consulted before.

H3d. Customers (19) should be consulted before.

H3e. Suppliers and customers (20) should be consulted before.

H3f. It allows establishing scenarios for market and technologies (15).

H3g. It allows be aware on opportunities and threats (24).

The identification of resources, capabilities and competences constraints is essential to review the strategic business plan and to promote changes in product portfolio, determining the firms grow. Commitment with resource allocation as well as business's core competencies are important factors in innovation product strategy, highlight Cooper & Edgett (2010). An earlier strategy adopted to provide resources is determinant for new product performance (Rodríguez-Pinto et al., 2012). The firm's capability may be linked to marketing or operational, aiming to accomplish production goals. Both capabilities marketing operational have influence on financial performance (Kamboj et al., 2015). At operational level, the interaction among activities in NPD could be studied earlier in the project planning, assessing uncertainties and risks that affects the project performance (León et al., 2013).

Within the industry, the innovation process requires creativity skills by multidisciplinary team (Bocken et al., 2014) and the involvement of the staff in each department is essential. Cross-functional integration could improve NPD success, mainly in the case of high uncertainty and risk (Gemser & Leenders, 2011). Leadership of managers is essential to integrate the staff, unifying efforts toward innovation (Hage et al., 2008). The following hypotheses are stated for the activity A4:

A4. Identify resources, capability and competencies constraints (4)

H4a. It allows determining how much the company can grow considering the limitations of each department (25).

H4b. It allows reducing risks and uncertainties in decision-making (21).

2.2. Market scope

The perception of a market opportunity is a fundamental step in the NPD (Ulrich & Eppinger, 2011). As the consumer market changes quickly, organizations need to perceive these trends aiming to integrate all relevant information about consumers in NPD. Market dynamics can influence the project performance (Lee & Wong, 2011). In this context, marketing research, a critical task for the success of NPD, is important to identify market potential, customer preferences and competitive activity (Song & Montoya-Weiss, 1998). This contributes to identify trends in the market. As argued previously, investments and training are essential in the market area. Hence, the hypotheses for the activity A5 are:

A5. Evaluate existing products in the market (5)

H5a. It has to train professionals for both collection and interpretation data (22) before.

H5b. It has to invest in financial resources and time (23) before.

H5c. It allows identifying trends in the Market (26).

By marketing, firms can make their innovations perceived by customers as higher values (Brenes et al., 2014). The interactive process with customers allows the understanding of customers' needs as well as shaping future needs (Stanko & Bonner, 2013). This allows firms to identify new trends in the market. In addition, from identification of customer value, performing tests and comparative performance analysis could be carried out, allowing investments in marketing to increase sales. By sensory analysis, customers can perceive the main characteristics of the product. There are several techniques for listening to customers (Van Kleef et al., 2005). From these arguments, the hypotheses for the activity A6 are:

A6. Analyze customer value in a product (6)

H6a. It has to train professionals for both collection and interpretation data (22) before.

H6b. It has to invest in financial resources and time (23) before.

H6c. Allows performing tests and comparative performance analysis (27) in order to invest in marketing (28), and consequently increasing sales (29).

H6d. It allows identifying trends in the market (26).

The choice of markets with great opportunities is the strategy for the success of innovations (Cooper, 2001). The identification and assessment of new product opportunities are important elements to define the environment where the firm will compete, which can be evaluated by attractiveness and business strength (Cooper & Edgett, 2010). According to Cooper & Kleinschmidt (1986) more emphasis should be done on market studies, especially on initial screening activities and preliminary market assessment. Market study for new products allows revealing new trends (Stanko & Bonner, 2013). In order to develop this activity, the following elements are essential: market study, financial resources and time (Cooper, 1988). According to Lee & Wong (2011), more emphasis should be placed on learning practices, such as market assessment and test marketing. Thus, we state the following hypotheses for the activity A7 are:

A7. Study the market for new products (7)

H7a. It has to train professionals for both collection and interpretation data (22) before.

H7b. It has to invest in financial resources and time (23) before.

H7c. It allows identifying trends in the market (26).

From identification of market trends, market outlook for new opportunities allows reviewing SBP and reducing risks and uncertainties. Seeking for new opportunities in the market is a strategy to reduce uncertainty. According to Poskela & Martinsuo (2009), market uncertainty is positively associated with strategic renewal. The hypotheses for the activity A8 are:

A8. Generate market outlook for new opportunities (8)

H8a. Identify trends in the market should be done before (26).

H8b. It allows reviewing the SBP subsequently (2).

H8c. It allows reducing risks and uncertainties in decision-making (21).

2.3. Product portfolio scope

After reviewing the business plan, an analysis in the portfolio may be required. New ideas should be established and pre-selected. Literature has highlighted the importance of customer integration in project portfolios (Tikkanen et al., 2007; Voss, 2012). A good relationship with supplier could allow innovative ideas and solutions in NPD projects, according to Sjoerdsma & Van Weele (2015). The relationship with suppliers could bring benefits for NPD; however, this involvement should be managed carefully due to risk with transactional inefficiencies, according to Yoo et al. (2015). Therefore, the hypotheses for the activity A9 are:

A9. Analyze the product portfolio (9)

H9a. Suppliers (18) should be consulted before.

H9b. Customers (19) should be consulted before.

H9c. Suppliers and customers (20) should be consulted before.

H9d. It allows establishing a list of ideas and pre-select them (10).

The ideas for new products can emerge internally or they can to generate from demand or market. The ideas are selected from criteria such as technical, commercial, strategic and financial (Chan et al., 2011). Ideas considered important for the activities of FEI are selected, refined and then more formally studied (Kurkkio et al., 2011). Considering the need for an agile NPD process, activities should be done more accelerated (Cooper, 2014). In this context, the pre-selection of ideas could reduce the meeting time between the development team and managers and it could allow pre-test with new product ideas, minimizing the development time. From these concepts, the hypotheses for the activity A10 are:

A10. Establish a list of ideas and pre-select (10)

H10a. Allows minimizing meeting time with development team and managers (30)

H10b. Allows conducting pre-tests with new products ideas to be prepared for possible changes in the environment (11).

Normally new ideas require input materials and preliminary tests, which could be carried out by simulation or in a laboratory (Kurkkio et al., 2011). This activity allows effectively proposing changes in the product portfolio and minimizing the development time of a new product. Hence, the hypotheses for the activity A11 are:

A11. Conduct pre-tests with new product ideas to be prepared for possible changes in the environment (11)

H11a. It allows proposing changes in the product portfolio (13).

H11b. It allows the minimizing development time of new products (31).

Literature has stressed the importance in the developing relationship with stakeholders in NPD, especially customers and suppliers. Patanakul (2015) highlights that stakeholders should understand the main reasons in portfolio decision-making for the transparency purpose in the NPD process. An efficient communication process between the company and stakeholder is important to create confidence (Pokharel, 2011). According to Kim & Wilemon (2002), the relationship withal supporters and partners consist in part of the strategy to manage the front-end of innovation in NPD. Porter (1987) affirms that shareholder value is created in a portfolio strategy. Brem & Voigt (2009) state that, after consultation with stakeholders, a scenario analysis is important to transfer new ideas to the innovation process. Based on this background, we state that the interaction between organization and stakeholders would be important to establish a scenario in order to propose changes in the product portfolio. From this, the hypotheses for the activity A12 are:

A12. Establish scenarios for portfolio – politic, economic, technology – (12).

H12a. Suppliers (18) should be consulted before.

H12b. Customers (19) should be consulted before.

H12c. Suppliers and customers (20) should be consulted before.

H12d. The top managers (32) should be consulted before.

H12e. Partners (33) should be consulted before.

H12f. Shareholders (34) should be consulted before.

H12g. It allows proposing changes in the product portfolio (13).

Changes in the product portfolio could bring new customers, affecting positively the financial performance; however, complementary technological capabilities could be necessary, implying investments in resources (Kang & Montoya, 2014). Both review of ideas and portfolio selection must be periodic, observing the available resources and other constraints (Archer & Ghasemzadeh, 1999). Depending on the product, pilot plant tests would be necessary for feasibility analysis (Frishammar et al., 2012). Thus, the hypotheses for the activity A13 are:

A13. Propose changes in the product portfolio (13)

H13a. Identify resources, capability and competences constraints (4) should be done before.

H13b. Conduct pre-tests with new products ideas to be prepared for possible changes in the environment (11) should be done before.

H13c. It allows sorting and prioritize ideas – approve, reject or freeze (35).

H13d. It allows the company to maintain and to gain new customers (36) to be more competitive (37).

Managers should balance the portfolio of products, examining the components as a whole. This activity aims to achieve equilibrium between short and long-term projects or high and low risk, following the business strategy (Project Management Institute, 2013). Many projects in the portfolio ends up competing with resources, jeopardizing the company (Archer & Ghasemzadeh, 1999). Therefore, a balanced portfolio reduces risks and uncertainties in decision-making.

After the selection of ideas about a new product, portfolio management is the next step. Portfolio management is defined by Project Management Institute (2013) as centralized management of one or more portfolios, including identification, prioritization, balancing, authorization, management and control of projects, programs and other works, aiming to reach the goal of the business. There are different manners to manage portfolios (Kester et al., 2009). Portfolio management should be formalized, mainly for those with a high level of complexity, aiming to reach a positive impact on their performance (Teller et al., 2012). The organization shall review and document the portfolio. The connection between customer and portfolio management has a positive impact on project portfolio success and is a way to better satisfy customer needs, according to Voss (2012). After balancing the portfolio, the organization should formally authorize the project planning for one or more products of the portfolio, and then carry out the report on the review of the product portfolio. Finally, the project may be approved or not by executive team. From theory, the hypotheses for the activity A14 are:

A14. Balance the portfolio of products (14)

H14a. Sorting and prioritize ideas (35) should be done before.

H14b. Determine criteria for portfolio management (38) should be done before

H14c. Allows reducing risks and uncertainties in decision-making (21)

H14d. Allows maximizing return on investment – ROI (39)

H14e. It allows submitting a list of the projects approved, deactivated and terminated (40); review and document the portfolio, and subsequently authorizing the project planning (41).

3. Methods

3.1. Research

The survey was carried out in the small, medium and large industries in Brazil. In this study, both food and furniture industries were chosen because these kinds of industries normally develop intense activities in NPD, featuring a wide portfolio of products. The research was carried out with managers who are decision makers responsible for R&D in companies.

A structured questionnaire was answered by 78 industries, 40 from the food sector and 38 from the furniture sector. In the first part of the questionnaire the following institutional information was requested: the productive sector (food or furniture), the size of industry (small, medium, large), formalized NPD (yes or not), production system (push type or pull type), innovation (radical and incremental). In this work, the number of employees defines the size of industries. In the second part of the questionnaire, two kinds of questions for each activity were made: firstly, on the *frequency* of conduction that activity using a Likert scale (never, almost never, sometimes, often, or always); secondly on the agreement with the *statements* (based on the hypothesis of the literature).

3.2. Statistical analysis

Hypothesis were tested for both frequency of activities developed by industries (A1...A14) and statements (H1a...H14e). The tests are done for proportion, taking into account the standard deviation $\sigma = \sqrt{p_o * (1 - p_o) / n}$, the z-score = $(p - p_o) / \sigma$ and the p-value = $1 - P(Z < z)$ with 95% confidence, where p is the proportion of the sample, p_o is the proportion of the population and n is the sample size. In this study, we assume the proportion of the population as fifty per cent (majority rule). We have established the following tests (Equations 1 and 2):

$$\text{Null hypothesis} \quad H_o : p \leq p_o \quad (1)$$

$$\text{Alternative hypothesis} \quad H_a : p > p_o \quad (2)$$

3.3. Model analysis

All hypotheses that are accepted are displayed in a Strategic Map. A preceding activity is linked to a subsequent activity. The links depend on the established hypotheses. For instance, considering the hypotheses (H1a and H1c linked to the activity A1) being tested and accepted, we have the following situations: *Establish scenarios for market and technologies (A15)* should be done before A1; *Define the scope to review the SBP (A1)* allows *defining the plan - actors, tasks and deadlines (A17)*. In this case, the sequence in the map is presented as follows (Figure 1).



Figure 1. Representation of activities sequence in the map.

Analysis to be carried out consists in observing the fundamental properties of maps (Eden, 2004). The activity with no out-arrow is a head and the activity with no in-arrow is a tail. Heads are goals to be reached while tails are options to develop strategies to reach goals. Activity linked to several arrows (immediate domain) are the most central and complex. The analysis of properties in this paper involves:

- Complexity – level of density measured in a cognitive map (Equation 3);
- Goals – heads with higher immediate domain;
- Potent goals – goals in more than one cluster;
- Options – tails with higher immediate domain (Equation 4);
- Potent options – options positioned in more than one cluster;
- Strategies – activities between options and goals with higher immediate domain;
- Potent strategies – strategies on more than one cluster.

The map complexity analysis takes into account arrows and activities in order to assess the interconnected network density. In other words, a dense map has much more arrows than activities. Let A be an arrow and C be an activity in the map. The complexity ratio (CR) is determined according to Equation 3. Higher ratio means that the map is densely connected, indicating a high level of complexity.

$$CR = \frac{\sum A}{\sum C} \tag{3}$$

The domain analysis allows seeking the centrality of the issue. Complex activities in terms of the domain are those most central. In practical terms, the domain analysis allows finding the main options and strategies to reach goals. For each activity, considering in-arrows (A_{in}) and out-arrow (A_{out}) linked to it, the *immediate domain (ID)* is determined by Equation 4.

$$ID = \sum A_{in} + \sum A_{out} \tag{4}$$

4. Results

The survey shows that, in both sectors, most of the industries studied adopt the formalized NPD process. The production system in the food sector depends on the industry while in the furniture sector most of the industries adopt a production pull system. Most industries have adopted incremental innovation. The profile of the industries surveyed is shown in the Table 1.

Table 1. Profile of the industries.

	Food sector	Furniture sector
Small industries (<100 employees)	11%	21%
Medium industries	36%	56%
Large industries (> 500 employees)	53%	24%
Formalized NPD process	86%	91%
Not formalized NPD process	14%	9%
Production Pull System	56%	76%
Production Push System	44%	24%
Incremental Innovation	67%	59%
Radical and Incremental Innovation	33%	41%

In this study, NPD activities are developed by the industries often or always. Table 2 shows the percentage of each activity developed by the companies ($\rho\%$), the z-score, the p-value and the decision. All the hypotheses proposed on the frequency of developed activities presented in the Theoretical foundation (A1...A14) were accepted as shown in the Table 2.

Table 2. Frequency of developed activities.

	Food				Furniture			
	ρ (%)	=	ρ -value	Decision	ρ (%)	=	ρ -value	Decision
A1	72	2.78	0.0027	Accepted	75	3.08	0.0010	Accepted
A2	70	2.53	0.0057	Accepted	75	3.08	0.0010	Accepted
A3	72	2.78	0.0027	Accepted	97	5.79	0.0000	Accepted
A4	85	4.43	0.0000	Accepted	82	3.95	0.0000	Accepted
A5	92	5.31	0.0000	Accepted	91	5.05	0.0000	Accepted
A6	72	2.78	0.0027	Accepted	91	5.05	0.0000	Accepted
A7	71	2.66	0.0039	Accepted	80	3.70	0.0001	Accepted
A8	83	4.17	0.0000	Accepted	72	2.71	0.0034	Accepted
A9	76	3.29	0.0005	Accepted	88	4.68	0.0000	Accepted
A10	86	4.55	0.0000	Accepted	85	4.32	0.0000	Accepted
A11	72	2.78	0.0027	Accepted	94	5.42	0.0000	Accepted
A12	68	2.28	0.0113	Accepted	67	2.10	0.0179	Accepted
A13	68	2.28	0.0113	Accepted	81	3.82	0.0001	Accepted
A14	70	2.53	0.0057	Accepted	75	3.08	0.0010	Accepted

As for statements, statistical tests show that not all hypotheses were accepted. The results are shown in the Table 3. For instance, the activities A9 (*H9*) and A12 (*H12*) obtained the highest number of rejected hypothesis, which are linked stakeholders consulting to define product portfolio. The hypotheses *H1b* (*Examine the need to revise the strategy*) and *H8b* (*review the SBP after generate market outlook*) were accepted by food and rejected by furniture industries. On the contrary, the following hypotheses were accepted by furniture, but they were rejected by food industries: *H3e* (*suppliers and customers should be consulted before identify changes in market and technologies*), *H12e* (*partners should be consulted before establish portfolio scenario*) and *H12f* (*shareholders should be consulted before establish portfolio scenario*).

Table 3. The hypotheses stated.

<i>Ha</i>	Food				Furniture			
	ρ (%)	=	ρ -value	Decision	ρ (%)	=	ρ -value	Decision
H1a	90.0	5.06	0.0000	Accepted	97.4	5.84	0.0000	Accepted
H1b	72.5	2.85	0.0022	Accepted	60.5	1.30	0.0968	Rejected
H1c	85.0	4.43	0.0000	Accepted	71.1	2.60	0.0047	Accepted
H2a	52.5	0.32	0.3745	Rejected	50.0	0.00	0.5000	Rejected
H2b	17.5	- 4.11	1.0000	Rejected	13.2	- 4.54	1.0000	Rejected
H2c	25.0	- 3.16	0.9992	Rejected	15.8	- 4.22	1.0000	Rejected
H2d	50.0	0.00	0.5000	Rejected	13.2	- 4.54	1.0000	Rejected
H2e	80.0	3.79	0.0001	Accepted	86.8	4.54	0.0000	Accepted
H2g	82.5	4.11	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H2h	65.0	1.90	0.0287	Accepted	68.4	2.27	0.0116	Accepted
H3a	92.5	5.38	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H3b	92.5	5.38	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H3c	25.0	- 3.16	0.9992	Rejected	15.8	- 4.22	1.0000	Rejected
H3d	22.5	- 3.48	0.9997	Rejected	15.8	- 4.22	1.0000	Rejected
H3e	47.5	- 0.32	0.6255	Rejected	73.7	2.92	0.0018	Accepted
H3f	82.5	4.11	0.0000	Accepted	68.4	2.27	0.0116	Accepted
H3g	92.5	5.38	0.0000	Accepted	86.8	4.54	0.0000	Accepted
H4a	80.0	3.79	0.0001	Accepted	68.4	2.27	0.0116	Accepted
H4b	82.5	4.11	0.0000	Accepted	73.7	2.92	0.0018	Accepted
H5a	80.0	3.79	0.0001	Accepted	78.9	3.57	0.0002	Accepted
H5b	80.0	3.79	0.0001	Accepted	78.9	3.57	0.0002	Accepted
H5c	75.0	3.16	0.0008	Accepted	76.3	3.24	0.0006	Accepted
H6a	95.0	5.69	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H6b	95.0	5.69	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H6c	87.5	4.74	0.0000	Accepted	94.7	5.52	0.0000	Accepted
H6d	87.5	4.74	0.0000	Accepted	71.1	2.60	0.0047	Accepted
H7a	75.0	3.16	0.0008	Accepted	78.9	3.57	0.0002	Accepted
H7b	75.0	3.16	0.0008	Accepted	78.9	3.57	0.0002	Accepted
H7c	85.0	4.43	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H8a	67.5	2.21	0.0000	Accepted	71.1	2.60	0.0047	Accepted
H8b	82.5	4.11	0.0000	Accepted	57.9	0.97	0.1660	Rejected
H8c	67.5	2.21	0.0000	Accepted	73.7	2.92	0.0018	Accepted
H9a	17.5	- 4.11	1.0000	Rejected	13.2	- 4.54	1.0000	Rejected
H9b	17.5	- 4.11	1.0000	Rejected	28.9	- 2.60	0.9953	Rejected
H9c	47.5	- 0.32	0.6255	Rejected	31.6	- 2.27	0.9884	Rejected
H9d	72.5	2.85	0.0000	Accepted	84.2	4.22	0.0000	Accepted
H10a	85.0	4.43	0.0000	Accepted	76.3	3.24	0.0006	Accepted
H10b	77.5	3.48	0.0000	Accepted	71.1	2.60	0.0047	Accepted
H11a	50.0	0.00	0.5000	Rejected	60.5	1.30	0.0968	Accepted
H11b	65.0	1.90	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H12a	15.0	- 4.43	1.0000	Rejected	15.8	- 4.22	1.0000	Rejected
H12b	15.0	- 4.43	1.0000	Rejected	13.2	- 4.54	1.0000	Rejected
H12c	47.5	- 0.32	0.6255	Rejected	52.6	0.32	0.3745	Rejected

Table 3. Continued...

<i>Ha</i>	Food				Furniture			
	ρ (%)	=	ρ -value	Decision	ρ (%)	=	ρ -value	Decision
H12d	82.5	4.11	0.0000	Accepted	84.2	4.22	0.0000	Accepted
H12e	60.0	1.26	0.1038	Rejected	73.7	2.92	0.0018	Accepted
H12f	60.0	1.26	0.1038	Rejected	73.7	2.92	0.0018	Accepted
H12g	85.0	4.43	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H13a	90.0	5.06	0.0000	Accepted	76.3	3.24	0.0006	Accepted
H13b	50.0	0.00	0.5000	Rejected	73.7	0.00	0.5000	Rejected
H13c	92.5	5.38	0.0000	Accepted	84.2	4.22	0.0000	Accepted
H13d	80.0	3.79	0.0000	Accepted	89.5	4.87	0.0000	Accepted
H14a	92.5	5.38	0.0000	Accepted	94.7	5.52	0.0000	Accepted
H14b	87.5	4.74	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H14c	82.5	4.11	0.0000	Accepted	76.3	3.24	0.0006	Accepted
H14d	87.5	4.74	0.0000	Accepted	86.8	4.54	0.0000	Accepted
H14e	90.0	5.06	0.0000	Accepted	71.1	2.60	0.0047	Accepted
H8a	67.5	2.21	0.0000	Accepted	71.1	2.60	0.0047	Accepted
H8b	82.5	4.11	0.0000	Accepted	57.9	0.97	0.1660	Rejected
H8c	67.5	2.21	0.0000	Accepted	73.7	2.92	0.0018	Accepted
H9a	17.5	- 4.11	1.0000	Rejected	13.2	- 4.54	1.0000	Rejected
H9b	17.5	- 4.11	1.0000	Rejected	28.9	- 2.60	0.9953	Rejected
H9c	47.5	- 0.32	0.6255	Rejected	31.6	- 2.27	0.9884	Rejected
H9d	72.5	2.85	0.0000	Accepted	84.2	4.22	0.0000	Accepted
H10a	85.0	4.43	0.0000	Accepted	76.3	3.24	0.0006	Accepted
H10b	77.5	3.48	0.0000	Accepted	71.1	2.60	0.0047	Accepted
H11a	50.0	0.00	0.5000	Rejected	60.5	1.30	0.0968	Accepted
H11b	65.0	1.90	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H12a	15.0	- 4.43	1.0000	Rejected	15.8	- 4.22	1.0000	Rejected
H12b	15.0	- 4.43	1.0000	Rejected	13.2	- 4.54	1.0000	Rejected
H12c	47.5	- 0.32	0.6255	Rejected	52.6	0.32	0.3745	Rejected
H12d	82.5	4.11	0.0000	Accepted	84.2	4.22	0.0000	Accepted
H12e	60.0	1.26	0.1038	Rejected	73.7	2.92	0.0018	Accepted
H12f	60.0	1.26	0.1038	Rejected	73.7	2.92	0.0018	Accepted
H12g	85.0	4.43	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H13a	90.0	5.06	0.0000	Accepted	76.3	3.24	0.0006	Accepted
H13b	50.0	0.00	0.5000	Rejected	73.7	0.00	0.5000	Rejected
H13c	92.5	5.38	0.0000	Accepted	84.2	4.22	0.0000	Accepted
H13d	80.0	3.79	0.0000	Accepted	89.5	4.87	0.0000	Accepted
H14a	92.5	5.38	0.0000	Accepted	94.7	5.52	0.0000	Accepted
H14b	87.5	4.74	0.0000	Accepted	78.9	3.57	0.0002	Accepted
H14c	82.5	4.11	0.0000	Accepted	76.3	3.24	0.0006	Accepted
H14d	87.5	4.74	0.0000	Accepted	86.8	4.54	0.0000	Accepted
H14e	90.0	5.06	0.0000	Accepted	71.1	2.60	0.0047	Accepted

From the accepted hypotheses, models for both food and furniture industries are presented in the Figure 2 and Figure 3, respectively. Activities in the FEI are structured in an intricate network with a high level of complexity ($CR= 1.2$). As can be seen in the maps, activities are not linear. There is a high level of interdependence among them. Some activities are related to more than one scope.

The domain analysis (Table 4) indicates that activities with high immediate domain (ID) are most complex and consequently are the most central.

The ID (Table 4) was calculated from Equation 3, taking into account the links for each box in the Figure 2 and Figure 3. All activities are important in FEI, obviously; however, the activities with a higher domain analysis are the focus for the companies studied. Analysis reveals that the main goal of the industries is reducing risks and uncertainties in decision making.

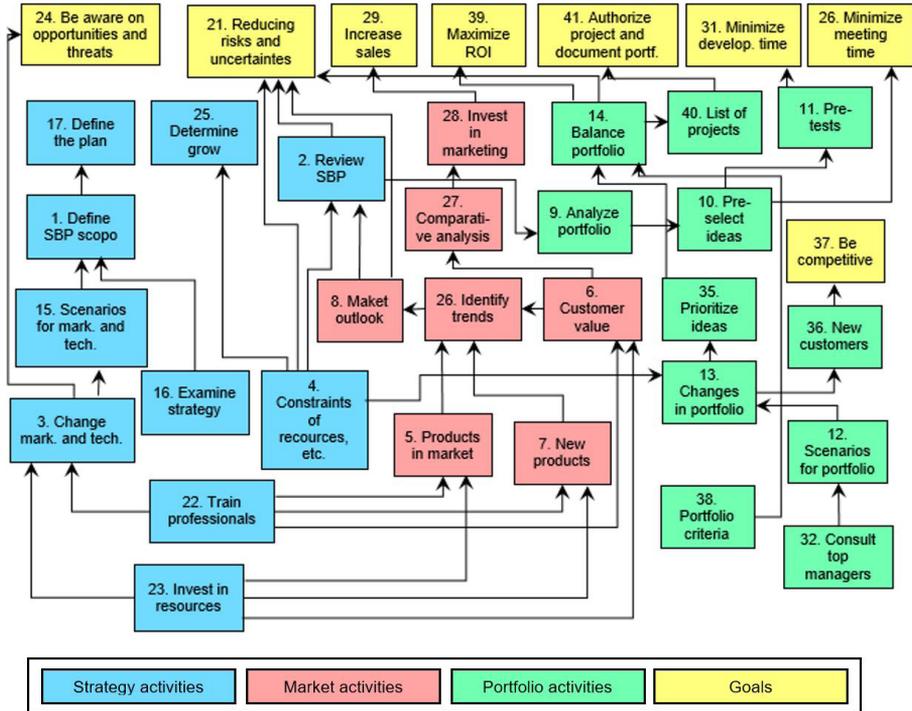


Figure 2. Model for food industries.

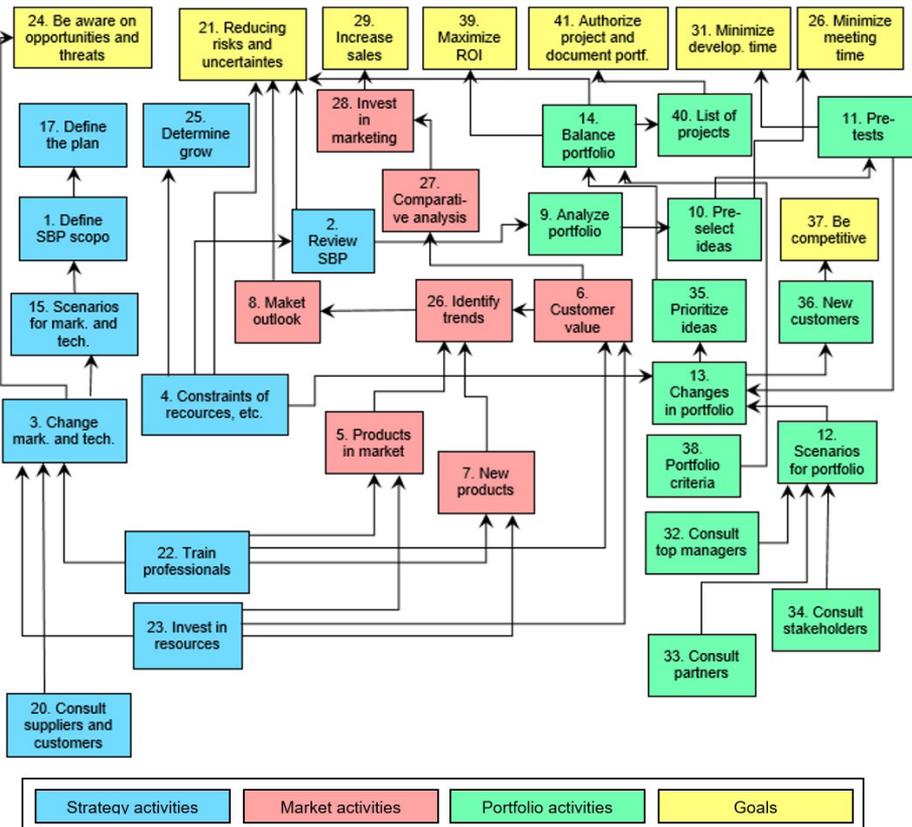


Figure 3. Model for furniture industries.

Table 4. Domain analysis.

	Activities	Scopes	ID
Goal	Reducing risks and uncertainties	Strategic, Market and Portfolio	4
Strategies	Identify changes in market and technologies	Strategic	5
	Balance the portfolio of products	Portfolio	5
	Propose changes in the product portfolio	Strategic and Portfolio	5
	Establish scenarios for portfolio	Portfolio	4
	Analyze customer value in a product	Strategic and Market	4
	Identify trends in the market	Market	4
Options	Train Professionals	Strategic and Market	4
	Invest in resources	Strategic and Market	4
	Identify constraints of resources, capability and competencies	Strategic and Portfolio	4

5. Discussion

According to the final model (Figure 2 and Figure 3), all activities are structured in a dense and intricate network with a high level of complexity, and hierarchically. The index (*CR*) to measure the complexity level of the model found here is near the typical ratio expected by Eden (2004). Some activities belong to one scope (strategic, market or portfolio) while others are related to more than one scope. According to Griffin et al. (2014), the innovation process is not linear for radical innovations. A great part of industries surveyed here is incremental. Even for this kind of innovation, our study reveals that activities in FEI are not linear. Some activities could be developed in parallel, but there are activities that should be developed subsequently to others. A high level of interdependence among activities is verified. Some activities behave as options and other as strategies to reach goals. The model is presented hierarchically structured, following the concepts pointed out by Clark (1985). Regarding the actors' cognitive effort to structure activities in NPD, the hierarchical structure can be explained from the psychological point of view. Aiming to understand his world, the human being tends to organize concepts hierarchically, building constructs superordinate to others (Eden, 1988).

Our research shows that reducing risks and uncertainties in decision-making is the main companies' concern for Strategic, Market and Portfolio Scopes. This can be observed in the model of both sectors. The SPP developed by companies foresees a large number of activities in FEI in order to obtain relevant information. According to Kim & Wilemon (2002), reliable information can reduce uncertainties in the front-end. In this sense, Mendes & Toledo (2012) studied the FEI practices of a set of medical-hospital equipment industries and one of the recommendations was that these industries need to reduce the uncertainties inherent in pre-development by considering a system of information that includes strategic, market, technological and organizational information.

The identification of changes in market and technologies depends on training professionals to collect and to interpret data. This result is in accordance with the theory (Lee & Wong, 2011). Analysis of customer value in a product allows identifying trends in the market and performing tests and comparative analysis, and depends on training and investments in resources. Literature has highlighted the importance of industries in maintain stakeholder engaged in NPD. Our study reveals that food industries do not consult customers and suppliers to identify changes in the market. Instead, they prefer to perform sensory analysis. As for partners and shareholders, only furniture industries consult these stakeholders to establish a scenario for product portfolio.

Changes in the product portfolio depends on the constraints of resources, capability and competencies, performing tests of new products and scenarios. This is in accordance with theory. Balancing the portfolio of products has impact on risk minimization. This result is in accordance with the proposition done by Archer & Ghasemzadeh (1999). Reviewing the SBP has impact on risk minimization. Dynamic environments offer opportunities for change (Aspara et al., 2011) and, in turn, changes could accentuate risks and uncertainties (Calantone et al., 2003).

6. Conclusions

A large amount of activities has been developed by industries in FEI. Our study revealed that, excepting some specificities between sectors or companies, there is a basic group of activities common to industries. This is supported by the high percentage of industries that develop the same activities often or always. The large amount of activities and the complexity in structuring them denote that companies are concerned to reduce uncertainty and risk by intensifying the planning phase.

Our work has two implications for both theoretical and managerial areas. First of all, our results show that activities in FEI are interrelated and hierarchically structured. This changes the current view on structuring activities in NPD. Activities are not merely a roll for ordering in a whole manner due to the high level of interdependence among them. A possible prioritizing process should take into account such aspects. This insight can guide future research on the prioritizing process for decision-making. As for the strategic planning in FEI, more focus should be done by researchers on the information system concerning three Scopes (strategic, market and portfolio) in order to reduce risks and uncertainties in decision-making as early as possible, a concern great companies. Complementing the theoretical contribution, we can highlight the methodology employed in this work. The approach combining survey and Cognitive Maps is a novelty so far and it can be guide other researches.

The second implication is related to managers and practitioners in NPD, since the model can guide them in structuring FEI activities throughout SPP. A flexible process is necessary in order to take into account the need of companies and the specificities of each project (Dibrell et al., 2014; Nobelius & Trygg, 2002). Anyway, the model can help this complex task in the following manner: the interdependence among activities in terms of preceding-subsequent actions can aid managers and practitioners to define the sequencing of its development; the company's concerns and its objectives are clearer from the strategic map; the main strategies and the main options to develop them are evidenced in the map; the uncertainties are reduced taking into account all the necessary information in the initial planning.

The model found here highlights the interconnection with diverse Scopes and areas. Hence, the contribution from all departments is important in FEI during SPP, requiring a greater integration within the company. Another aspect is that, in this work, the model is and the outcome of food and furniture industries, but it could be applied to any organization from any sector. Regarding the specificity of each company and each project as well as the fuzziness characteristics of the FEI, mainly due to elements such as complex information and tacit knowledge in a conflicting organizational environment, the model contributes for the NPD area, regarding the necessary flexibility to deal with the interrelated activities in FEI. Finally, further research could be carried out in other sectors for the comparative purpose.

There are a lot of activities in NPD and this work covers a significant part of them. As this research is limited to a certain set of activities, other possibilities could be explored in future works. For instance, Technology Roadmapping can be integrated into the front-end of new product development, allowing the alignment of business and communication of product innovation goals (Oliveira & Rozenfeld, 2010). Future research could be test Technology Roadmapping and other activities in order to improve the model.

Acknowledgements

We thank the CAPES, a public institution linked to the Brazilian Ministry of Education. In addition, the authors also wish to thank the anonymous reviewers and the editorial team of the Journal for their valuable suggestions.

References

- Acur, N., Kandemir, D., & Boer, H. (2012). Strategic alignment and new product development: drivers and performance effects. *Journal of Product Innovation Management*, 29(2), 304-318. <http://dx.doi.org/10.1111/j.1540-5885.2011.00897.x>.
- Archer, N. P., & Ghasemzadeh, F. (1999). An integrated framework for project portfolio selection. *International Journal of Project Management*, 17(4), 207-216. [http://dx.doi.org/10.1016/S0263-7863\(98\)00032-5](http://dx.doi.org/10.1016/S0263-7863(98)00032-5).
- Aspara, J., Lamberg, J.-A., Laukia, A., & Tikkanen, H. (2011). Strategic management of business model transformation: lessons from Nokia. *Management Decision*, 49(4), 622-647. <http://dx.doi.org/10.1108/00251741111126521>.
- Bocken, N. M. P., Farracho, M., Bosworth, R., & Kemp, R. (2014). The front-end of eco-innovation for eco-innovative small and medium sized companies. *Journal of Engineering and Technology Management*, 31, 43-57. <http://dx.doi.org/10.1016/j.jengtecman.2013.10.004>.
- Brem, A., & Voigt, K. I. (2009). Integration of market pull and technology push in the corporate front end and innovation management: insights from the German software industry. *Technovation*, 29(5), 351-367. <http://dx.doi.org/10.1016/j.technovation.2008.06.003>.
- Brenes, E. R., Montoya, D., & Ciravegna, L. (2014). Differentiation strategies in emerging markets: the case of Latin American agribusinesses. *Journal of Business Research*, 67(5), 847-855. <http://dx.doi.org/10.1016/j.jbusres.2013.07.003>.
- Calantone, R., Garcia, R., & Dröge, C. (2003). The effects of environmental turbulence on new product development strategy planning. *Journal of Product Innovation Management*, 20(2), 90-103. <http://dx.doi.org/10.1111/1540-5885.2002003>.
- Chan, S. L., Ip, W. H. I., & Kwong, C. K. (2011). Closing the loop between design and market for new product idea screening decisions. *Expert Systems with Applications*, 38(6), 7729-7737. <http://dx.doi.org/10.1016/j.eswa.2010.12.136>.
- Clark, K. B. (1985). The interaction of design hierarchies and market concepts in technological evolution. *Research Policy*, 14(5), 235-251. [http://dx.doi.org/10.1016/0048-7333\(85\)90007-1](http://dx.doi.org/10.1016/0048-7333(85)90007-1).
- Clark, K. B., & Fujimoto, T. (1991). *Product Development Performance: strategy, organization and management in the world auto industry*. Boston: Harvard Business School Press.

- Cooper, R. G. (1988). Predevelopment activities determine product success. *Industrial Marketing Management*, 17(3), 237-247. [http://dx.doi.org/10.1016/0019-8501\(88\)90007-7](http://dx.doi.org/10.1016/0019-8501(88)90007-7).
- Cooper, R. G. (2001). *Winning at new products* (3rd ed.). New York: Basic Books.
- Cooper, R. G. (2014). What's next? After stage-gate: progressive companies are developing a new generation of idea-to-launch process. *Research Technology Management*, 57(1), 20-31. <http://dx.doi.org/10.5437/08956308X5606963>.
- Cooper, R. G., & Edgett, S. J. (2010). Developing a product innovation and technology strategy for your business: a framework for developing a product innovation strategy includes defining innovation goals and objectives, selecting strategic arenas, developing a strategic map, and allocating resources. *Research Technology Management*, 53(3), 33-40.
- Cooper, R. G., & Kleinschmidt, E. J. (1986). An investigation into the new product process: steps, deficiencies, and Impact. *Journal of Product Innovation Management*, 3(2), 71-85. [http://dx.doi.org/10.1016/0737-6782\(86\)90030-5](http://dx.doi.org/10.1016/0737-6782(86)90030-5).
- Dibrell, C., Craig, J. B., & Neubaum, D. O. (2014). Linking the formal strategic planning process, planning flexibility, and innovativeness to firm performance. *Journal of Business Research*, 67(9), 2000-2007. <http://dx.doi.org/10.1016/j.jbusres.2013.10.011>.
- Eden, C. (1988). Cognitive mapping. *European Journal of Operational Research*, 36(1), 1-13. [http://dx.doi.org/10.1016/0377-2217\(88\)90002-1](http://dx.doi.org/10.1016/0377-2217(88)90002-1).
- Eden, C. (2004). Analyzing cognitive maps to help structure issues or problems. *European Journal of Operational Research*, 159(3), 673-686. [http://dx.doi.org/10.1016/S0377-2217\(03\)00431-4](http://dx.doi.org/10.1016/S0377-2217(03)00431-4).
- Frishammar, J., Lichtenthaler, U., & Kurkkio, M. (2012). The front end in non-assembled product development: a multiple case study of mineral- and metal firms. *Journal of Engineering and Technology Management*, 29(4), 468-488. <http://dx.doi.org/10.1016/j.jengtecman.2012.07.001>.
- Gemser, G., & Leenders, M. A. A. M. (2011). Managing cross-functional cooperation for new product development success. *Long Range Planning*, 44(1), 26-41. <http://dx.doi.org/10.1016/j.lrp.2010.11.001>.
- Griffin, A., Price, R. L., Vojak, B. A., & Hoffman, N. (2014). Serial Innovators' processes: how they overcome barriers to creating radical innovations. *Industrial Marketing Management*, 43(8), 1362-1371. <http://dx.doi.org/10.1016/j.indmarman.2014.08.010>.
- Hage, J., Jordan, G., Mote, J., & Whitestone, Y. (2008). Designing and facilitating collaboration in R&D: a case study. *Journal of Engineering and Technology Management*, 25(4), 256-268. <http://dx.doi.org/10.1016/j.jengtecman.2008.10.005>.
- Hanafizadeh, P., Kazazi, A., & Bolhasani, A. J. (2011). Portfolio design for investment companies through scenario planning. *Management Decision*, 49(4), 513-532. <http://dx.doi.org/10.1108/00251741111126468>.
- Harris, L. C., & Ogbonna, E. (2006). Initiating strategic planning. *Journal of Business Research*, 59(1), 100-111. <http://dx.doi.org/10.1016/j.jbusres.2005.02.003>.
- Heising, W. (2012). The integration of ideation and project portfolio management: a key factor for sustainable success. *International Journal of Project Management*, 30(5), 582-595. <http://dx.doi.org/10.1016/j.ijproman.2012.01.014>.
- Kahn, K. B., Barczak, G., Nicholas, J., Ledwith, A., & Perks, H. (2012). An examination of new product development best practice. *Journal of Product Innovation Management*, 29(2), 180-192. <http://dx.doi.org/10.1111/j.1540-5885.2011.00888.x>.
- Kamboj, S., Goyal, P., & Rahman, Z. (2015). A resource-based view on marketing capability, operations capability and financial performance: an empirical examination of mediating role. *Procedia: Social and Behavioral Sciences*, 189, 406-415. <http://dx.doi.org/10.1016/j.sbspro.2015.03.201>.
- Kang, W., & Montoya, M. (2014). The impact of product portfolio strategy on financial performance: the roles of product development and market entry decisions. *Journal of Product Innovation Management*, 31(3), 516-534. <http://dx.doi.org/10.1111/jpim.12111>.
- Kester, L., Hultink, E. J., & Lauche, K. (2009). Portfolio decision-making genres: a case study. *Journal of Engineering and Technology Management*, 26(4), 327-341. <http://dx.doi.org/10.1016/j.jengtecman.2009.10.006>.
- Khurana, A., & Rosenthal, S. R. (1998). Towards holistic "front ends" in new product development. *Journal of Product Innovation Management*, 15(1), 57-74. [http://dx.doi.org/10.1016/S0737-6782\(97\)00066-0](http://dx.doi.org/10.1016/S0737-6782(97)00066-0).
- Kim, J., & Wilemon, D. (2002). Focusing the fuzzy front-end in new product development. *R&D Management*, 32(4), 269-279. <http://dx.doi.org/10.1111/1467-9310.00259>.
- Koen, P. A., Bertels, H. M. J., & Kleinschmidt, E. J. (2014). Managing the front end of innovation. Part II: results from a three-year study: effective front-end activities were found to be significantly for incremental and radical projects. *Research Technology Management*, 57(3), 25-35.
- Kurkkio, M. J., Frishammar, J., & Lichtenthaler, U. (2011). Where process development begins: a multiple case study of front end activities in process firms. *Technovation*, 31(9), 490-504. <http://dx.doi.org/10.1016/j.technovation.2011.05.004>.
- Lee, K. B., & Wong, V. (2011). Identifying the moderating influences of external environments on new product development process. *Technovation*, 31(10-11), 598-612. <http://dx.doi.org/10.1016/j.technovation.2011.06.007>.
- León, H. C. M., Farris, J. A., Letens, G., & Hernandez, A. (2013). An analytical management framework for new product development processes featuring uncertain iterations. *Journal of Engineering and Technology Management*, 30(1), 45-71. <http://dx.doi.org/10.1016/j.jengtecman.2012.11.004>.
- Markham, S. K. (2013). The impact of front-end innovation activities on product performance. *Journal of Product Innovation Management*, 30(S1), 77-92. <http://dx.doi.org/10.1111/jpim.12065>.
- Marzagaõ, D. S. L., & Carvalho, M. M. (2014). Disfunções na implementação da gestão de portfólio de projetos: um estudo quantitativo. *Production*, 24(2), 337-350. <http://dx.doi.org/10.1590/S0103-65132013005000018>.
- Melander, L., & Tell, F. (2014). Uncertainty in collaborative NPD: effects on the selection of technology and supplier. *Journal of Engineering and Technology Management*, 31, 103-119. <http://dx.doi.org/10.1016/j.jengtecman.2013.10.009>.
- Mendes, G. H. S., & Toledo, J. C. (2012). Gestão do pré-desenvolvimento de produto: estudo de casos na indústria de equipamentos médico-hospitalares. *Production*, 22(3), 391-404. <http://dx.doi.org/10.1590/S0103-65132012005000031>.
- Meskendahl, S. (2010). The influence of business strategy on project portfolio management and its success: a conceptual framework. *International Journal of Project Management*, 28(8), 807-817. <http://dx.doi.org/10.1016/j.ijproman.2010.06.007>.

- Moeckel, A. (2009). *Sistematização da gestão de portfólio na fase de planejamento estratégico de produtos* (Doctor thesis). Programa de Pós-graduação em Engenharia Mecânica, Universidade Federal de Santa Catarina, Florianópolis. Retrieved in 5 October 2016, from <https://repositorio.ufsc.br/bitstream/handle/123456789/92218/272136.pdf?sequence=1>
- Mullins, J. W., & Sutherland, D. H. (1998). New product development in rapidly changing markets: an exploratory study. *Journal of Product Innovation Management*, 15(3), 224-236. [http://dx.doi.org/10.1016/S0737-6782\(97\)00081-7](http://dx.doi.org/10.1016/S0737-6782(97)00081-7).
- Nobelius, D., & Trygg, L. (2002). Stop chasing the Front End process: management of the early phases in product development projects. *International Journal of Project Management*, 20(5), 331-340. [http://dx.doi.org/10.1016/S0263-7863\(01\)00030-8](http://dx.doi.org/10.1016/S0263-7863(01)00030-8).
- Oliveira, M. G., & Rozenfeld, H. (2010). Integrating technology roadmapping and portfolio management at the front-end of new product development. *Technological Forecasting and Social Change*, 77(8), 1339-1354. <http://dx.doi.org/10.1016/j.techfore.2010.07.015>.
- Patanakul, P. (2015). Key attributes of effectiveness in managing project portfolio. *International Journal of Project Management*, 33(5), 1084-1097. <http://dx.doi.org/10.1016/j.ijproman.2015.01.004>.
- Pokharel, S. (2011). Stakeholders' roles in virtual project environment: a case study. *Journal of Engineering and Technology Management*, 28(3), 201-214. <http://dx.doi.org/10.1016/j.jengtecman.2011.03.006>.
- Porter, M. E. (1987). From competitive advantage to corporate strategy. *Harvard Business Review*, 65(3), 43-59. http://dx.doi.org/10.1007/978-1-349-20317-8_17. PMID:17183795.
- Poskela, J., & Martinsuo, M. (2009). Management control and strategic renewal in the front end of innovation. *Journal of Product Innovation Management*, 26(6), 671-684. <http://dx.doi.org/10.1111/j.1540-5885.2009.00692.x>.
- Postma, T. J. B. M., Broekhuizen, T., & Van den Bosch, F. (2012). The contribution of scenario analysis to the front-end of new product development. *Futures*, 44(6), 642-654. <http://dx.doi.org/10.1016/j.futures.2012.02.001>.
- Project Management Institute – PMI. (2013). *A guide to the project management body of knowledge* (5th ed.). Newtown Square: PMI.
- Riel, A., Neumann, M., & Tichkiewitch, S. (2013). Structuring the early fuzzy front-end to manage ideation for new product development. *CIRP Annals: Manufacturing Technology*, 62(1), 107-110. <http://dx.doi.org/10.1016/j.cirp.2013.03.128>.
- Rodríguez-Pinto, J., Rodríguez-Escudero, A. I., & Gutiérrez-Cillán, J. (2012). How market entry order mediates the influence of firm resources on new product performance. *Journal of Engineering and Technology Management*, 29(2), 241-264. <http://dx.doi.org/10.1016/j.jengtecman.2012.03.001>.
- Rozenfeld, H., Forcellini, F. A., Amaral, D. C., Toledo, J. C., Silva, S. L., Alliprandini, D. H., & Scalice, R. K. (2006). *Gestão de desenvolvimento de produtos - uma referência para a melhoria do processo*. São Paulo: Saraiva.
- Ruff, F. (2015). The advanced role of corporate foresight in innovation and strategic management: reflections on practical experiences from the automotive industry. *Technological Forecasting and Social Change*, 101, 37-48. <http://dx.doi.org/10.1016/j.techfore.2014.07.013>.
- Schoonmaker, M., Carayannis, E., & Rau, P. (2012). The role of marketing activities in the fuzzy front end of innovation: a study of the biotech industry. *The Journal of Technology Transfer*, 38(6), 850-872. <http://dx.doi.org/10.1007/s10961-012-9296-1>.
- Sjoerdsma, M., & Van Weele, A. J. (2015). Managing supplier relationships in a new product development context. *Journal of Purchasing and Supply Management*, 21(3), 192-203. <http://dx.doi.org/10.1016/j.pursup.2015.05.002>.
- Smals, R. G. M., & Smits, A. A. J. (2012). Value for value: the dynamics of supplier value in collaborative new product development. *Industrial Marketing Management*, 41(1), 156-165. <http://dx.doi.org/10.1016/j.indmarman.2011.11.022>.
- Song, X. M., & Montoya-Weiss, M. M. (1998). Critical development activities for really new versus incremental products. *Journal of Product Innovation Management*, 15(2), 124-135. [http://dx.doi.org/10.1016/S0737-6782\(97\)00077-5](http://dx.doi.org/10.1016/S0737-6782(97)00077-5).
- Song, Y.-I., Lee, D.-H., Lee, Y.-G., & Chung, Y.-C. (2007). Managing uncertainty and ambiguity in frontier R&D projects: a Korean case study. *Journal of Engineering and Technology Management*, 24(3), 231-250. <http://dx.doi.org/10.1016/j.jengtecman.2007.05.001>.
- Stanko, M. A., & Bonner, J. M. (2013). Projective customer competence: projecting future customer needs that drive innovation performance. *Industrial Marketing Management*, 42(8), 1255-1265. <http://dx.doi.org/10.1016/j.indmarman.2013.05.016>.
- Teller, J., Unger, B. N., Kock, A., & Gemünden, H. G. (2012). Formalization of project portfolio management: The moderating role of project portfolio complexity. *International Journal of Project Management*, 30(5), 596-607. <http://dx.doi.org/10.1016/j.ijproman.2012.01.020>.
- Tikkanen, H., Kujala, J., & Artto, K. (2007). The marketing strategy of a projectbased firm: the four portfolios framework. *Industrial Marketing Management*, 36(2), 194-205. <http://dx.doi.org/10.1016/j.indmarman.2006.03.006>.
- Ulrich, K. T., & Eppinger, S. D. (2011). *Product design and development*. New York: McGraw-Hill.
- Van Kleef, E., Van Trijp, H. C. M., & Luning, P. (2005). Consumer research in the early stages of new product development: a critical review of methods and techniques. *Food Quality and Preference*, 16(3), 181-201. <http://dx.doi.org/10.1016/j.foodqual.2004.05.012>.
- Verworn, B., Herstatt, C., & Nagahira, A. (2008). The fuzzy front end of Japanese new product development projects: impact on success and differences between incremental and radical projects. *R & D Management*, 38(1), 1-19. <http://dx.doi.org/10.1111/j.1467-9310.2007.00492.x>.
- Voss, M. (2012). Impact of customer integration on project portfolio management and its success: developing a conceptual framework. *International Journal of Project Management*, 30(5), 567-581. <http://dx.doi.org/10.1016/j.ijproman.2012.01.017>.
- Yoo, S. H., Shin, H., & Park, M.-S. (2015). New product development and the effect of supplier involvement. *Omega*, 51, 107-120. <http://dx.doi.org/10.1016/j.omega.2014.09.005>.

Received: Oct. 5, 2016
Accepted: June 19, 2017