INNOVATION VALUE CHAIN
PERFORMANCE BASED ON
KNOWLEDGE

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The present paper aims to contribute to the planning guidelines in the innovation value chain management field. Therefore, it addresses the influence of the stakeholders’ knowledge on the performance of innovation value chain in product development processes applied to technology-based companies under uncertainty and constraint conditions. Thus, a survey was developed with experts chosen by their technical-scientific criteria and knowledge on the subject. The data were extracted by means of a judgment matrix. To reduce subjectivity in the results, the following method was used: Law of Categorical Judgment - psychometric scaling (Thurstone, 1927). The results produced are satisfactory, validating the proposed procedure for Value Chain Management (VCM).

Palavras-chaves: Planning, Knowledge; Value Chain Performance; Innovation; Product Development Process; Uncertainty and Restraint.
1. Introduction

The value chain management – VCM has for quite some time presented challenges within a wide diversity of extremely complex events, all of which in an unsure and risky context that can affect the flux of decisions and the desired levels of performance, hence frustrating expectations for stability. It must be acknowledged that risks can be brought about from different origins and scenarios. With time, this eventually leads to changes in the configuration of the chain. Consequently, it is considered one of the main challenges of value chain management, which basically consists of creating integrated structures of decision making in an extensive universe containing multiple organizations. This requires an integrated and shared decision structure that involves key business processes, concerning efficient coordination of functional-temporal company-client (CHENG, YEH, AND TU, 2008; POWER, 2005; BLOS, et. al., 2009; FAWCETT, et. al., 2009; GODSELL, BIRTWISTLE, and HOEK, 2010; KIM, 2006).

The characteristics of the value chain differ a great deal, therefore becoming the object of analysis equally differentiated. The good practice recommends fulfilling a sequence of articulated actions, which consist of the following phases: (i) planning the necessities; (ii) institutionalization and formation of a project team and determination of the communication procedures; (iii) the objectives’ consolidation, results and performance’s goal of the value chain; (iv) study of the costs, prescriptions, flows of box; (v) study of the social impacts; (vi) analysis, allocation and management of risks (preliminary evaluation), etc. Many times the projects are made impracticable still in the act of planning, hence becoming unsustainable. One of the aspects that deserves to be highlighted is the occurrence of errors in the management of the value chain, which often results in a non-fulfillment of the established goals and performance. It is imposed thus that the efficiency in the planning of the value chain propitiates more efficient decisions, diminishing the improvisation and improvement of the involved team. Traditionally, the planning phase "sins" when it is elaborated without support of the knowledge that really is essential in the management of the value chain.

The knowledge may represent a strategic tool, increasing the institutional capacity of the Entrepreneurs in their assignments of formulation, evaluation and execution of such projects (FLETCHER, YIANNIS, and POLYCHRONAKIS, 2007; HANISCH et. al., 2009; KANNABIRAN, 2009; KAYAKUTLU and BUYUKOZKAN, 2010). The knowledge would work as a facilitator instrument of improvement, contributing for the quality of services and the enhancement of the agility to decide. Monitoring the performance of value chain from a knowledge perspective requires that the appropriate monitoring procedures are in place and operational (FLETCHER, YIANNIS, and POLYCHRONAKIS, 2007; GODSELL, BIRTWISTLE, and HOEK, 2010; SVENSSON, 2007). Generally, a keen eye must be kept on the knowledge household of value chain. Especially important is watching the external environment for new events that may have impacts on the way value chain deals with knowledge shown as “incoming” arrows that will influence on the performance of value chain. In order to improve the performance of the entire value chain, it is necessary to cross the boundaries of individual companies and consolidate the entire chain, in other words, a cohesive and integrated system to increase the chain’s knowledge flow.
In this spectrum, the present paper aims to contribute to the planning guidelines in the innovation value chain field. Therefore, it addresses the influence of the stakeholders’ knowledge on the performance of innovation value chain in product development processes applied to technology-based companies under uncertainty and constraint conditions. Innovation events, such as the introduction of a new product or process, represent the end of a series of knowledge models and the beginning of a process of value creation (ROPERA, JUN DUB, LOVE, 2008). In the next section of the paper we introduce our conceptual model and detail our hypotheses and their underlying justification. Subsequently we outline our methodological approach and detail our results. We end with a consideration of what has been lessons learned and contributions.

2. Conceptual model: key constructs and hypotheses

This section examines the conceptual model (Figure 1) and develops the theoretically justified hypotheses.

![Conceptual model](image)

Figure 1: Conceptual model – dependent, moderating and independent variables

This contribution focuses on knowledge priorities for performance in the innovation value chain. Based on a methodological strategy, explained later, which included interviews with Brazilian specialists, the priorities have been systemized and prioritized. Thus, the findings are based on that analysis. The hypothesis: The highest degree of knowledge implies the highest degree of value chain performance in innovation

**Independent Variables**

The independent variables were extracted from the specialized literature and assessed by experts for confirmation. The following independent variables were identified: Stakeholders’ knowledge: C1: R&D (Shelanski and Klein, 1995); c2: Customers (Joshi and Sharma, 2004); c3: Suppliers (Horn, 2005; Smith and Tranfield, 2005); c4: External consultants (Horn, 2005; Smith and Tranfield, 2005); c5: Competitors (Hemphill, 2003; Link et al, 2005); c6: Joint ventures (Hemphill, 2003; Link et al, 2005); and c7: universities/other public research centers (ROPER et al., 2004).
Smith and Tranfield, 2005), the content was derived from the construction used by Dow et al. (1999) and Forza and Filippini (1998). For the R&D variable, the construct was mainly derived from Shelanski and Klein (1995); GUPTA, Wilemon, and Atuahene-Gima (2000) and Chiesa et al. (1996), which capture two important R&D aspects: capabilities and connections. As for the variable External Consultants, the construct is based on Horn (2005); Smith and Ranfield (2005). The variable Competitors is based on Hemphill (2003); Link et al (2005). Finally, the variable Joint Ventures is based on Hemphill (2003) and Link et al (2005).

**Moderating Variables**

The moderator or controls variables are the risks and uncertainties of innovation. These involve research, discovery and commercialization. Commercialization is obviously the result of research and this refers to the potential risks of scientific and technological development up to mass production. The market represents the main risks, which are encountered by the market agents engaging in economic activities. When new products enter the market, competitors quickly intervene, which will result in a competitive risk (WU et. al. 2010). The technological innovation risks refer to the uncertainties of technology, market and benefits for the institutional environment.

**Dependent variables**

Once it is validated that the performance of innovation value chain in the product development technology (PDT) process contains multifaceted aspects, a construct is used to measure the performance of the innovation value chain in the technology development technology (PDT). The dimensions extracted from the specialized literature for the dependent variable - Performance of the innovation value chain in PDT - is as follows: P1: Customer Impact; P2: Business results and; P3: Sales percentage derived from new products.

**3. Methodology: Steps and Implementation**

The objective of the methodological procedures used is to achieve the intended goal and solve the research problem. These procedures can potentialize and attenuate the subjective differences that are included. Although the procedures are for a specific application (PDT), by detailing and describing the main elements of each procedure established so they may serve as auxiliary material in other applications. Thus, this research is characterized by a combination of sequential qualitative and quantitative approaches.

The qualitative analysis provides information to plan and execute the quantitative stage. With the research problem, the study explores the specialized literature on the research subject, which helps identify the variables that comprise the model and formulate the hypotheses of the study. Based on the model outlined (Figure 1), this work proposes a series of hypotheses that show relationships between the knowledge generated from each stakeholder (source) and the performance in the innovation value chain. The data are extracted at two stages, based on the specialized literature to identify the knowledge variables of the stakeholders and performance variables of the PDT innovation value chain. These variables will then undergo confirmation and judgment by the experts, through a survey, in technology-based companies (in Brazil).

Firstly, the degree of influence of the stakeholders’ (sources) knowledge on the overall performance of the innovation value chain in technology development process was investigated in technology-based companies under uncertainty and constraints. In a risk situation, future events have probable outcomes (MILLIKEN, 1987). Uncertainty with regards
to risk is a condition that renders difficult to predict the likelihood of various future events (MILLIKEN, 1987). It is believed that the presence of risks can increase the positive effects of the stakeholders’ knowledge influence on the performance of the PDT innovation value chain. Additionally, an environment of uncertainty can weaken the influence of knowledge on the performance of innovation value chain. In an environment of unpredictability and unexpected change these variations or disturbances can make the results highly subjective.

These disorders and unpredictability can specifically result in significant disruptions along the value chain. In this study the risks of innovation as disruption conditions are reaffirmed. To investigate the stakeholders’ (sources) knowledge influence on the innovation value chain performance in a global perspective, the law of Categorical Judgment (Thurstone, 1927) - psychometric scaling method was used. This methodology is recommended in conditions of uncertainty and constraint, because they include highly complex and subjective events, in which the experts (judges) are able to express their preferences at different moments. Thus, the data collection instrument (Judgment matrix) is based on Thurstone’s Law of Categorical Judgment method - psychometric scaling, submitted to the experts in the Survey, who have technical and scientific knowledge on the study object. This is a mental behavior model that explains the experts’ preference structure for a set of stimuli. The model starts with the experts’ mental behavior in order to explain the preference structure of a judge (individual) related to a set of stimuli. It should be noted that the judges’ preferences are manifested at different moments [...], and the scale values will vary depending on the mental process dynamics. One of the motivations relates to the characteristics of the problem, which through the structures it should solve and explain the preferences of the experts. This mechanism only perceives manifestations that are represented by the choices revealed empirically through the frequencies related to the preferences. After this procedure, the stakeholders’ (sources) knowledge influence on the performance of innovation value chain was examined, considering the dimensions individually (customer impact, return on sales and sales percentage derived from innovation).

3.1 Sample and Data Collection

This section details the elements that comprise the sample as well as the data extraction structure used in the study. Thus, the data were first extracted from the specialized literature on the subject under investigation to prepare the scalar-type data collection instrument (assessment matrix), based on Thurstone’s law of Categorical Judgment psychometric scaling method. Once the construct and content were defined, the instrument was submitted to the experts’ (judges) assessment in order to confirm the scale with regards to construction and content. Thus, the stakeholders (knowledge sources) from diverse backgrounds and scenarios, directly and/or indirectly involved with the technology developing process in the innovation value chain in PDT were identified.

We first identified the following stakeholders (knowledge sources): (i) research and development - R&D; (ii) Customers; (iii) Suppliers; (iv) External consultants; (v) Competitors; (vi) Joint ventures and (vii) universities/other public research centers. After the knowledge sources survey, the stakeholders’ main spectrum of activities considered in the PDP/PDT were identified. The activities identified were: I – Project Scope; II – Concept Development; III – Prototype Development; IV – Integration of Subsystems; V – Prototype Production; VI – Market introduction; VII – Post Product Launch. It should be noted that the activities presented for the case in question are for the technology development process (PDT). The results obtained are as follows: I – Invention; II – Project Scope; III – Concept
Development; IV – Concept Development; V – Technology Optimization; VI – Technology Transfer.

After identifying the technology development stages, the next step was to identify the knowledge needed to converge each of the stages in the PDT stages. The results showed the following knowledge according to the PDT steps (CLARK AND WHEELWRIGHT, 1992; COOPER AND KLEINSCHMIDT, 1987): (i) Strategic Planning of the company; (ii) Technology Strategy determination; (iii) technology; (iv) consumer; (v) Generation of ideas; (vi) project scope development; (vii) mapping future plans; (viii) patent survey; (vix) identifying opportunities; others. Thus, the influence of the stakeholders’ knowledge on the performance of innovation value chain in PDT under constraint and uncertainty was based on the activities and their respective technology development stages.

Taking into consideration that development projects of new technologies involve high risks and uncertainty (COOPER, 2006). To reduce the risks and uncertainties of innovative projects in this research, the analogy of Cooper (2006) was applied, which proposes executing various activities throughout technology development, considering that there is an organized arrangement among them, hence enabling to better manage the process. These projects are not developed properly, influenced by the instability of technology and markets that change unexpectedly. Furthermore, these projects can be developed as part of product designs, causing conflicts when developing an innovative product (CLARK and WHEELWRIGHT, 1993).

After this procedure, the performance dimensions of the innovation value chain in PDT were identified (based on the literature). The results showed the following dimensions: customer impact, business and sales return derived from innovations. For the case in question, the influence of knowledge on the overall performance of the innovation value chain was considered. Next, we identified the influence of knowledge according to the dimensions individually considered: customer impact, business return and sales percentage derived from innovation. Technology-based companies are organizations that structure their activities in the development and production of new products and/or processes, based on the systematic application of scientific and technological knowledge and the use of advanced and pioneering techniques. These companies have knowledge and technical-scientific information and a high rate of R&D expenditures as their main input. The main element that distinguishes this category of companies from others is the risk of activities that includes innovations. And this is because they operate in specific sectors with non-standard technologies.

The influence of knowledge on the overall global performance is detailed in the next section, using the LJC psychometric scaling. In summary, the results were extracted from the literature and then confirmed and validated by experts that were selected by their technical-scientific criterion on the object, with their experiences/practices and/or knowledge about product development, technological innovation and organizational management in technology-based companies in Brazil. Twelve experts were selected. The instrument was submitted to the experts via e-mail and through personal interviews. The final response rate was of 97%. More than half of the respondents were managers or supervisors, followed by senior managers (general manager or director), representing 40%. The remainder held or hold various management positions in technology innovation and product development.

3.2 Result and Analyses
As referenced earlier, the influence of knowledge on overall performance was conducted by means of the Thurstone’s LJC psychometric scaling method. The method allows a scale by importance. Thus, let \( \pi_{ij} = \text{Prob} \{ O_i \in C_1 \cup C_2 \cup \ldots \cup C_j \} \), the probability of stimulus \( O_i \) located in one of the first \( j \) categories ordered increasingly \( C_1, C_2, \ldots, C_j \). It can be written that \( \pi_{ij} = \text{Prob} \{ O_i \in C_1 \cup C_2 \cup \ldots \cup C_j \} = \text{Prob} \{ e_i \leq n_j \} \). With the hypotheses formulated, it follows that:

\[
\pi_{ij} = \text{Prob} \{ e_i - n_j \} = \text{Prob} \left[ \frac{(e_i - n_j) - (\mu - c_j)}{\sqrt{V(e_i - n_j)}} \leq \frac{(\mu - c_j)}{\sqrt{V(e_i - n_j)}} \right]
\]

That is: \( \pi_{ij} = \text{Prob} \left[ N(0,1) \leq \frac{(\mu - c_j)}{\sqrt{V(e_i - n_j)}} \right] \)

Where \( \pi_{ij} \) is an estimator of \( \pi_{ij} \) and considering value \( Z_{ij} \) such that, \( \text{Prob}[N(0,1) \leq Z_{ij}] = \pi_{ij} \), we have \( \frac{(\mu - c_j)}{\sqrt{V(e_i - n_j)}} = -Z_{ij} \), Where \( \mu \) is value of scale.

The experts (judges) express their preferences with pairs of stimuli (knowledge), and these were submitted to the ordinal categories \( C_1=5^{th} \) place; \( C_2=4^{th} \) place; \( C_3=3^{rd} \); \( C_4=2^{nd} \) place; \( C_5=1^{st} \). These events occur in different moments, in which the scale values vary depending on the dynamics of their own mental process, which result in replacing the idea of preference for the probability of preferences. The procedures to apply the instrument are systematized in the following steps: Step 1: Determining the frequencies of preferences for pairs of stimuli (Knowledge), where \( O_i \) is equal to Knowledge and \( O_j \) to the experts – \( O_j \). The systemized data were extracted from the experts’ preference regarding Knowledge (through field research using an assessment questionnaire/matrix). Knowledge appears as stimuli submitted to the ordinal categories. Step 2: Determination of the frequencies of ordinal categories, based on the data extracted from the previous step. The matrix \( [\pi_{ij}] \) of the cumulative relative frequencies is then calculated. The results are classified in ascending order of importance. To better understand the technique, we recommend the following literature (Souza, 1988; Thurstone (1927). Step 3: To determine the matrix \( [\pi_{ij}] \) of the cumulative relative frequencies from the results of the frequencies of ordinal categories we calculate the matrix of the cumulative relative frequencies. Step 4: To determine the inverse of the standard normal cumulative frequencies (INPFA), from the results obtained in the previous step, calculate the inverse of the standard normal cumulative frequencies.

The results reflect the experts’ preference probabilities in relation to stimuli (knowledge). The results are detailed to follow.
Table 1: Probability Intensity of Knowledge Influence on Performance in the Innovation value chain

The application of Thurstone’s LJC method, of mental decision, resulted in the preferences obtained ($\mu_i = -\sum_{j=1}^{4} Z_{ij} / 4$), in order of increasing priority. The order found was: first the R&D knowledge and in second place the knowledge generated from Customers. Investment policies have been strongly oriented to R&D. R&D has become a strategic development leverage for companies seeking to achieve world class status (HENDRY, 1998).

This result confirms the hypothesis. The confirmation of this hypothesis is a preliminary confirmation of the positive influence of the stakeholders’ knowledge on the performance of innovation value chain in PDT. Long considered an innovation indicator, formal research and development activities do not necessarily result in a higher level of product and process innovation ([TÖDTLING et al., 2009]). R&D is still considered useful to develop new products and manufacturing processes, and also to preserve and increase the company’s expertise in the field of business intelligence (KARLSSON and OLSSON, 1998).

The presence of R&D creates an organizational setting that is favorable to questioning, promoting corporate/company flexibility, with an ability to integrate new concepts and adaptability to market changes (FREEL, 2000). In addition, the knowledge and past experience gained with R&D, as well as their lasting and not sporadic existence, renders it instrumental to innovation (BROUWER and KLEINKNECHT, 1996). R&D and innovation are susceptible to sectorial influences [...] (BECHEIKH et al., 2006B). Product innovation is considered stronger in high-technology sectors [...] (SUBRAHMANYA, 2005). Moreover, the central element is the internal role of R&D to maximize the benefits of innovation from other forms of knowledge (LOVE and ROPER, 2008). It should be noted that companies with a strong customer focus are able to anticipate the needs of current and latent customers (Paladino, 2008). Bastic and Leskovar-Špacapan (2006) state that customer-focused companies focus on Product innovation versus process innovation and continuously collect information on the needs of competitors and target customers, and check their ability to use this information to create superior customer value. A company’s strong customer-focus can lead to an emphasis on innovation that is derived from the desire to continually adapt to customer needs (SANTOS-VIJANDE and ALVAREZ-GONZALEZ, 2007). Rowley (2002) calls attention to the fact that client knowledge enables the companies’ regrouping and creation of incremental value. And within this perspective, Garcia-Murillo and Annabi (2002) show that companies should take every opportunity to interact with customers in order to enrich their customer knowledge base. Consequently, a company can gain a thorough understanding of its customers, thus better able to meet their demands.

4. Final Words: Lessons Learned
Product development process (PDP) has received special attention from companies due to it is recognized as a source of competitive profits. Continued innovation of products, services, technology and the organization itself, has been one way to keep a business on its feet during the turbulent 1990s (COZIJNSEN, VRAKKING, AND IJZERLOO, 2000). Thus, The present work intends to contribute to the innovative planning guidelines in the field of product development. The knowledge may represent a strategic tool, increasing the institutional capacity of organisations and the Entrepreneurs in their assignments of formulation, evaluation and execution of such projects. The knowledge would work as a facilitator instrument of improvement, contributing for the quality of services and the enhancement of the agility to decide.

Several conclusions can be drawn from the results of this research. It is essential to measure the contribution of knowledge in the value chain performance. The performance of the value chain is an interdisciplinary and multidimensional concept that considers several areas of knowledge. The sample data supported the conceptual model derived from the literature. The confirmation of the general model proposed was important because it empirically evidenced that knowledge from R&D sources is considered the greatest influence on the performance of innovation value chain.

In this scenario, our methodological contribution is highlighted, because it provides support to the critical priorities in order to implement this project, and is also directed to building up knowledge as a key element for product development. We look forward to a more practical and efficient orientation that supports its long-term goals, thus assuring national competitiveness concerning the category of priorities. By gathering the cognitive elements, it can be seen that this strategy requires a priority dynamics, which depends on the initial state of product development process, on the concrete characteristics of the projects and on an innovation policy and cognitive problems that emerge during practice, always placing in view new contents. For this, priority research must be permanently and recurrently applied. Moreover, it is important that this method be used in other applications. Also, it is recommended testing the hypothesis by giving the decisions environment of that category of projects an intelligent treatment, by means of this research’s systematic knowledge, which makes decisions more efficient concerning the development and management of product development projects.

Few studies have investigated the influence of knowledge on PDP under constraint conditions. It is hoped that this study will stimulate a broad debate on the issue and it is acknowledged that more studies are needed to build more robust results in the near future. In addition, the study is limited to technology-based companies, opening the possibility for significant results. Moreover, the measurement of qualitative variables is a highly subjective factor. All data were collected transversally, and therefore what can be concluded is that the variables and their effects are related to a single point in time, thereby showing a limiting factor.

Finally, there may errors deriving from various origins such as incomplete sampling bases, among others. Some key priorities are proposed for future studies. We acknowledge the importance of replicating this study and repeating this testing model approach, using a completely new sample from other sectors. Interesting comparisons could also be carried out, as for instance applying the procedure adopted here in another country, in order to compare the results. Within this spectrum, this methodology does not claim to be complete, but it is our intent to make it a generator of strategic elements for the development of innovation projects.
This is where the knowledge Management becomes important, since it is a key instrument for project development in such a complex issue, as it is the case of product development.

References


