Knowledge build-up high complexity environment: towards on the innovation value chain performance in the product development process under uncertainty and restraint

Selma Regina Martins Oliveira*

Department of Business Administration,
University of São Paulo,
Av. Arlindo Gomes Rodrigues, 1082,
CEP 38406231, Uberlândia, MG, Brazil
Fax: +55 (34) 3-216-1940
E-mail: selmaregina@webmail.uft.edu.br
*Corresponding author

Roberto Sbragia

Department of Business Administration,
University of São Paulo,
Av. Prof. Luciano Gualberto, 908 – Sala E-194,
CEP 05508-010, São Paulo, SP, Brazil
Fax::+55 (11) 3818-4048
E-mail: sbragia@usp.br

Abstract: This work intends to contribute to the planning guidelines in the field of value chain management (VCM). Thus, it develops a model reference proposal supported by the definition of a highly complex environment of knowledge towards on the innovation value chain performance in the product/technology development process (PDP) applied to technology-based companies under uncertainty and restraint. This stage considers a sequence of systematic procedures in the following phases:

1 determining the information needs in two stages
2 determination of knowledge objects.

The results produced are satisfactory, validating the proposed procedure for VCM.

Keywords: planning; model reference; knowledge build-up high complexity environment; value chain performance; product development process; PDP.

Reference to this paper should be made as follows: Oliveira, S.R.M. and Sbragia, R. (2012) 'Knowledge build-up high complexity environment: towards on the innovation value chain performance in the product development process under uncertainty and restraint', *Int. J. Enterprise Network Management*, Vol. 5, No. 2, pp.97–125.

Biographical notes: Selma Regina Martins Oliveira holds a Master in Civil Engineering from the University of Brasilia. She received her PhD in Production Engineering from University of São Paulo, São Carlos, Brazil in 2009. She is a Professor in the Department of Administration and Accountant at the University of Federal Tocantins, Brazil. Her main research interest focuses on the analysis of the innovation, knowledge management, projects, product development and supply chain.

Roberto Sbragia holds a Master in Business Administration from the University of São Paulo. He received his PhD in Business Administration at University of São Paulo, São Paulo, Brazil, in 1982. He completed post-doctoral stage in R&D management in the Department of Industrial Engineering and Management Sciences at Northwestern University in 1986. He is a Full Professor in the Department of Business Administration at the University of São Paulo, Brazil. His main research interest focuses on the management of the innovation and project management. On these topics he has presented studies at national and international scientific congresses, which have been published in national and international journals.

1 Introduction

Post-industrial organisations today are knowledge-based organisations and this success and survival depend on creativity, innovation, discovery and inventiveness. Companies that offer products that are adapted to the needs and wants of target customers and that market them faster and more efficiently than their competitors are in a better position to create a sustainable competitive advantage (Hamel and Prahalad, 1994; Amit and Schoemaker, 1993; Nonaka and Takeuchi, 1995; Calantone et al., 1995). Competitive advantage is increasingly derived from knowledge and innovation in the creation of new products. Thus, innovative companies began to focus more on their own abilities to adapt to the economic value generated from their knowledge and innovations (Griliches, 1990, 1979; Teece, 1986; Winter, 1987).

Today's relevant changes have transformed organisational boundaries, making them more fluid and dynamic in response to the rapid pace of knowledge diffusion (Abrahamson, 1991; Griliches, 1990; Liebeskind, 1996; Teece, 1986), innovation and international competition (Chesbrough and Rosenbloom, 2002; Feenstra, 1998; Santos and Eisenhardt, 2005; Christensen and Raynor, 2003; Damanpour, 1991), thereby urging to reconsider how to prevail using innovation (Teece et al., 1997; Tidd et al., 1997; Teece, 1986; Wheelwright and Clark, 1992).

The concept of innovation is viewed in different ways in the literature. The concept of an innovation is often vigorously debated (Rosenberg, 1976). Innovation is a concept central to economic growth and can be a source of sustained competitive advantage to firms (Schumpeter, 1934; Tushman and O'Reilly, 1997). Nelson and Winter (1982) and Dosi (1982) view innovation as a process of improvement which may reside in the form of a problem solving activity (a new method) whereas Pavitt (1984) and Tidd et al. (1997) regard it as a process involving commercial use (a new business). Innovation is characterised by its uniqueness. Innovation may be highly radical, radical, intermediate, significant incremental, or minor incremental (Abetti, 2000). Highly radical innovation is a unique original product or system, which will obsolete existing ones. It is based on proprietary technology beyond the state of the art and major research and development (R&D). Radical innovation is a new product or system with original state-of-the-art proprietary technology that will significantly expand the capabilities of existing ones. It requires significant R&D. Intermediate innovation is a new product with proprietary technology, however it may be duplicated by others. It is a mix of standard and special features, and requires average R&D. Significant incremental innovation refers to significant extension of product characteristics with original adaptation of available technology. It is characterised with limited patent protection and minor R&D. Minor incremental innovation refers to incremental improvement over existing products. Innovation is also characterised by the question: to whom is it new (Johannessen et al., 2001)? This refers to the unit of adaptation, which can be examined in terms of newness to the company, newness to the market (Cooper, 1993; Kotabe and Swan, 1995) and newness to the industry (Johannessen et al., 2001).

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, which may result in business performance improvement (Ropera et al., 2008), based on the ability to counteract the vulnerability of globalisation in business operations [...] (Hoffman et al., 1998) and the ability to design and supply innovative products with great added value to customers in a timely matter, promoted by the value chain, to transform and make use of knowledge.

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 VCM, which basically consists of creating integrated structures of decision making in an extensive universe containing multiple organisations. This requires an integrated and shared decision structure that involves key business processes, concerning efficient coordination of functional-temporal company-client (Cheng et al., 2008; Power, 2005; Blos et al., 2009; Fawcett et al., 2009; Godsell et al., 2010; Halldórsson et al., 2007; Kim, 2006; Svensson, 2007).

Moreover, 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:

1 planning the necessities
2 institutionalisation and formation of a project team and determination of the communication procedures
3 the objectives' consolidation, results and performance's goal of the value chain
4 study of the costs, prescriptions, flows of box
5 study of the social impacts
6 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-fulfilment of the established goals and performance. Within this context, special attention needs to be paid to the measurement of 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 on the performance of the value chain. In this spectrum, the efficiency perspective of the VCM should be standardised in methods and techniques, hence enabling a correct planning of the decisions to be made. The focus of this contribution is on the definition of knowledge priorities.

Therefore, a support system for the decision of building up and managing VCM projects in the product development process (PDP) was developed based on the methodological support of the knowledge management (KM) theory. The aforementioned system considers a sequence of proceedings directed to prioritisation ranking of knowledge objects, so as to assist managers to choose priorities regarding information and theoretical knowledge.

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 and Polychronakis, 2007; Hanisch et al., 2009; Kannabiran, 2009; Kayakutlu and Büyüközkan, 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 and Polychronakis, 2007; Godsell et al., 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. Based on a modelling strategy, explained later on in this paper, including interviews with Brazilian specialists in PDP, the priorities have been systemised and prioritised. It is in this panorama that the modelling contribution of this project receives emphasis, as there is a support to the critical priorities to be considered in the list of necessary elements for implementing a project of this nature.

In this spectrum, this work intends to contribute to the planning guidelines in the field of VCM. Thus, it develops a model reference proposal supported by the definition of a highly complex environment of knowledge towards on the innovation value chain performance in the PDP, applied to technology-based companies under uncertainty and restraint. Formal performance and management has been said to improve an organisation's systems and outputs, and to facilitate long term planning and organisational control by identifying the factors that are critical to the organisation's success (Unahabhokha et al., 2007), as well management practices include the specification of which goals an organisation should aim to achieve.

The aforementioned system considers a sequence of proceedings directed to the prioritisation ranking of knowledge objects, so as to assist managers in choosing priorities regarding information and theoretical knowledge. This stage considers a sequence of systematic procedures in the following phases:

- *Phase 1:* Modelling of the information needs on the innovation value chain performance in the product/technology development process (PDP/PDT). This phase is structured in three stages:
  - a *Stage 1:* Determination of the CSF.
  - b *Stage 2:* Determination of the information areas.
  - c *Stage 3:* Prioritisation of the information needs starting from the crossing of CSF.
- *Phase 2:* Determination of the critical knowledge on the innovation value chain performance in the PDP/PDT. This phase has been subdivided as follows:
  - a *Stage 1:* Identification and acquisition of knowledge.
  - b *Stage 2:* Determination of the influence knowledge has on the value chain performance in innovation in the PDP/PDT under conditions of uncertainty and restraint.
  - c *Stage 3:* Representation of knowledge.

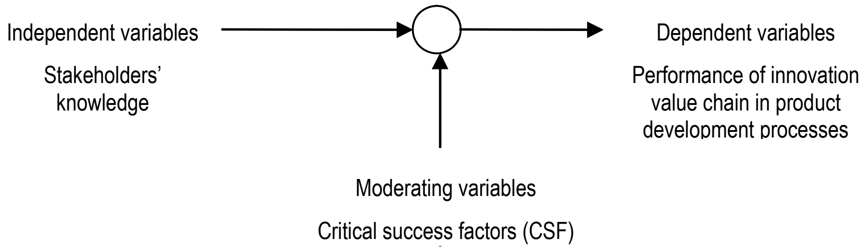
Several support instruments were used in the modelling elaboration in order to reduce subjectivity in the results: psychometric scales – Thurstone's law of comparative judgment (LCJ) and multi-criteria compromise programming, Electre III, and Promethee II. In the next section of the paper, we introduce our conceptual model. Subsequently, we outline our methological 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.

Hypotheses The highest degree of knowledge generated implies the highest degree of value chain performance in innovation. The analysis unit defined in this study is PDP/PDT.

Figure 1 Conceptual model – dependent, moderating and independent variables



- *Independent variables:* The independent variables were extracted from the specialised literature and assessed by experts for confirmation.
- *Moderating variables:* The moderator or controls variables are the critical success factors (CSF). The moderator variables were extracted from the specialised literature and assessed by experts for confirmation.
- *Dependent variables:* The dependent variables extracted from the specialised literature for the dependent variable – performance of the innovation value chain in PDP/PDT.

The focus of this contribution is on the definition of knowledge priorities. Based on a modelling strategy, explained later on in this paper, including interviews with Brazilian specialists in organisations, KM, product development and innovation management, the priorities have been systemised and prioritised. It is in this panorama that the modelling contribution of this project receives emphasis, as there is a support to the critical priorities to be considered in the list of necessary elements for implementing a project of this nature.

3 The method: structure

The building-up and the management of a value chain require highly complex analytical approaches, which include subjective elements. Thus, they demand the technical mastery of various technological, legal, financial and political aspects and procedures. KM may represent a strategic tool, increasing the institutional capacity of both the public sector and the entrepreneurs in their assignments of formulation, evaluation and execution of such projects (Mouritsen et al., 2004). The KM would work as a facilitator instrument of improvement, contributing for the quality of services and the enhancement of the agility to decide (Johannessen, 2008). Here, following the proposals of Bukowitz and Williams (2002), knowledge is considered as the elaborated, refined information, which is also able to self-evaluate its liability, relevance and importance. Knowledge is to be considered as the most important information as it includes a precise context, a concrete meaning, the respective interpretation and reflexion, adding personal wisdom and considering the widest implications (Davenport and Prusak, 1998; Kannan and Aulbur, 2004). Moresi (2001) proposes a chain composed of the following elements: processed data, elaborated information, synthesis by knowledge, and, finally, intelligence. The knowledge step converts the synthesis information into knowledge. After this synthesis, the information is gathered in blocks in such a way that they can later be used by specialists who filter it and standardise it in order to apply it to a specific situation. On that account, KM is defined as an integrated set of intervention tools (Probst et al., 2002) which consists of a systematic process in identifying, generating, distributing, applying and creating knowledge.

The present paper aims to contribute toward the planning guidelines in the field of VCM. Thus, it develops a model reference proposal supported by the definition of a highly complex environment of knowledge towards on the innovation value chain performance in the PDP/PDT under uncertainty and restraint. The aforementioned system considers a sequence of proceedings directed to the prioritisation ranking of knowledge objects, so as to assist managers in choosing priorities regarding information and theoretical knowledge. This stage considers a sequence of systematic procedures in the following phases:

- *Phase 1:* Modelling of the information needs on the innovation value chain performance in the PDP/PDT.
- *Phase 2:* Determination of the critical knowledge on the innovation value chain performance in the PDP/PDT.

The research was achieved through the intervention of specialists. The data collection was conducted by means of a semi-structured form, the scalar type in a trial matrix, to which experts ascribed their assessments. Several support instruments were used in the modelling elaboration in order to reduce subjectivity in the results: psychometric scales – Thurstone's LCJ, multi-criteria compromise programming, Electre III, and Promethee II; multivariate analysis. These different stages are detailed here.

3.1 Phase 1: Modelling of the information needs on the innovation value chain performance in the PDP/PDT

This phase is structured in three stages:

- *Stage 1:* Determination of the CSF on the innovation value chain in the PDP/PDT.
- *Stage 2:* Determination of the information areas on the innovation value chain in the PDP/PDT.
- *Stage 3:* Prioritisation of the information needs starting from the crossing of CSF on the innovation value chain in the PDP/PDT.

These different stages are detailed here:

3.1.1 Stage 1: Determination of CSF on the innovation value chain in the PDP/PDT

This phase is focused on determining the CSF, and is itself structured in two stages: identification of CSF and evaluation of CSF.

a *Identification:* The identification of CSF is based on the combination of various methods (Bruno and Liedecker, 1984):
   - environmental analysis (external variable: political, economical, legislation, technology, among others)
   - analysis of the industry structure (users' needs, the evolution of the demand, users' satisfaction level, their preferences and needs; technological innovations)
   - meeting with specialists and decision makers
   - the study of literature.

b *CSF evaluation:* After their identification, the CSF is evaluated in order to establish a ranking by relevance. Here the scale model of categorical judgments designed by Thurstone in 1927 has been adopted. The method allows a scale by importance.

Thus, let pij = Prob[$O_i \in C_1$ U C_2 U ... U C_j], the probability of stimulus Oi located in one of the j first categories ordered increasingly $C_1, C_2, \ldots, C_j$. It can be written that pij = Prob[$O_i \in C_1$ U C_2 U ... U C_j] = Prob[εi ≤ nj]. With the hypotheses formulated, it follows that:

$$\pi ij = \text{Prob}[\varepsilon i - nj] = \text{Prob}\left[\frac{(\varepsilon i - nj) - (\mu i - cj)}{\sqrt{V(\varepsilon i - nj)}} \leq \frac{(\mu i - cj)}{\sqrt{V(\varepsilon i - nj)}}\right]$$

That is:

$$\pi ij = \text{Prob}\left[N(0,1) \leq \frac{(\mu i - cj)}{\sqrt{V(\varepsilon i - nj)}}\right]$$

where πij is an estimator of πij and considering value Zij such that,

$$\text{Prob}[N(0,1) \leq Zij] = \hat{\pi} ij, \text{ we have } \frac{(\mu i - cj)}{\sqrt{V(\varepsilon i - nj)}} = -Zij.$$

The experts (judges) express their preferences with pairs of stimuli, and these were submitted to the ordinal categories C_1 = fifth place; C_2 = fourth place; C_3 = third place; C_4 = second place; C_5 = first place. 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 systematised in the following steps:

- *Step 1:* Determining the frequencies of preferences for pairs of stimuli (CSF), where Oi is equal to CSF and Oj to the experts – [Oi]Oj.
- Step 2: Determination of the frequencies of ordinal categories, based on the data extracted from the previous step. The matrix [πij] 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 [πij] 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 (CSF). Considering that C_1 contains less intense stimuli than C. In a psychological continuum the stimuli are translated by scale values of μi and the categories (C_1, C_2, C_3...), by an interval partition of the real line, such that C1 is represented by the interval (–∞, C_1) and C_2 represents the interval (m – 1, +∞). The result of preferences is then presented in order of increasing importance. The scale showed the experts' intensity probability of the preferences, by importance.

3.1.2 Stage 2: Identification of the areas of information on the innovation value chain in the PDP/PDT

The CSFs having already been defined, information areas are delimited with respect to the different CSFs.

3.1.3 Stage 3: Prioritisation of the information needs starting from the crossing of CSF on the innovation value chain performance in the PDP/PDT

Again, these information areas are ranked by application of the same categorical judgment method of Thurstone (1927) and put into relation with the CSF. At this moment, the following tools have been adopted:

a multi-objective utility – multi-attribute, in this case compromise programming™, which represent mathematically the decision makers' preference structure in situations of uncertainty

b selective, taken on account for the situation, Promethee II™

c Electre III™.

The critical knowledge for PDP is determined in the sequence.

3.2 Phase 2: Determination of the critical knowledge on the innovation value chain performance in the PDP

This phase has been subdivided as follows:

- *Stage 1:* Identification and acquisition of knowledge on the innovation value chain in the PDP/PDT.
- *Stage 2:* Determination of the influence knowledge has on the value chain performance in innovation in the PDP/PDT under conditions of uncertainty and restraint.
- *Stage 3:* Representation of knowledge on the innovation value chain in the PDP/PDT.

This proceeding is shown in details as to its structure.

3.2.1 Stage 1: Identification and acquisition of stakeholders' knowledge has on the value chain in the PDP/PDT

Initially, information topics which have been already identified will be elaborated, analysed and evaluated in order to be understood by the decision makers during the formulation and the management of a product/technology development project. Following this, they will be reviewed and organised and validated by PDP specialists. Afterwards, relevant theories and concepts are determined. With respect to the acquisition procedures, the different procedures of the process of acquisition represents the acquisition of the necessary knowledge, abilities and experiences to create and maintain the essential experiences and areas of information selected and mapped out (Thiel, 2002). Acquiring the knowledge (from specialists) implies, according to

Buchanan (1999), the obtaining of information from specialists and/or from documental sources, classifying it in a declarative and procedural fashion, codifying it in a format used by the system and validating the consistence of the codified knowledge with the existent one in the system.

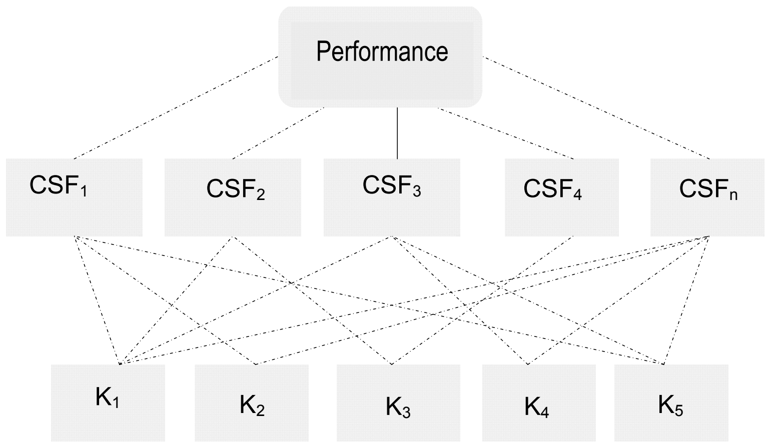
Therefore, at first, the way the conversion from information into knowledge is dealt with, which is the information to be understood by and useful for the decision making in projects in product development. First the information is gathered. Then the combination and internalisation is established by the explicit knowledge (information) so that it can be better understood and synthesised in order to be easily and quickly presented whenever possible (the information must be useful for the decision making and for that reason, it must be understood). In this work, we aim to elaborate the conversion of information into knowledge. The conversion (transformation) takes place as follows: first, the comparison of how the information related to a given situation can be compared to other known situations is established; second, the implications brought about by the information for the decision making are analysed and evaluated; third, the relation between new knowledge and that accumulated is established; fourth, what the decision makers expect from the information is checked.

The conversion of information into knowledge is assisted by the information maps (elaborated in the previous phase by areas, through analysis and evaluation of the information). We highlight that the information taken into account is both the ones externally and internally originated. The information from external origins has as a main goal to detect, beforehand, the long-term opportunities for the project. The internal information is important to establish the strategies, but it has to be of a broader scope than that used for operational management, because besides allowing the evaluation of the performance it also identifies its strengths and weaknesses. Following from this, the proceedings for the acquisition of theoretical background and concepts are dealt with. Such proceedings begin with the areas of information, one by one. In other words, which knowledge and theory are required to be known in order to ensure the success of projects in product/technology development in that area. After being identified and acquired, the knowledge is evaluated, with the aid of the method of categorical judgments of Thurstone (1927).

3.2.2 Stage 2: Determination of the influence of the stakeholders' knowledge has on the value chain performance in innovation in the PDP/PDT under conditions of uncertainty and restraint

To execute this step the multi-criteria method (Figure 2) was used: compromise programming, Electre III and Promethe II. The multi-criteria method was chosen due to its flexibility for the case in question, especially the subjective nature of the variables involved and the problem to be solved. The methods' application anticipates weight inferences to the evaluation criteria, expressing their relative importance. The relationship of significance between the evaluation criteria should reflect the stakeholders' resulting values within the study's scope of application, considering their specific expectations for each criterion. In this spectrum, defining the criteria weights is characterised as a group decision-making problem, which includes identifying the stakeholders' preferences and consensus. The definition of the evaluation criteria weights used in this work proposal was prepared by the experts, through a judgment matrix. With the judgment matrix results, these methods were applied: Promethee II, Electre III and compromise programming, to evaluate the stakeholders' knowledge influence on the value chain performance.

Figure 2 Knowledge on the value chain performance in innovation in the PDP/PDT under conditions of uncertainty and restraint (CSF)



3.2.3 *Stage 3: mental representation of stakeholders' knowledge on the value chain performance in innovation in the PDP/PDT under conditions of uncertainty and restraint*

The goal in building up a mental map is to make the decision makers of projects in PDP/PDT understand the decision context better. The data to be mapped out is extracted by various means, in this case, we have worked using semi-structured interviews, considered as a highly valuable instrument to identify the hierarchical structure and the dimensions of the judgment underlying the processes of classification. In this classification, the manner in which the specialists organise or structure this knowledge is described and so too is the process of classification by areas of information. To sum up, the development of this stage is structured as follows:

a after determining the priorities of knowledge assisted by the method of categorical judgments

b the development of mental maps by categories of area of information takes place.

As a support instrument, the software Statistica is used, which makes the process of organising easy in the space the intensity of the decision makers' preferences in relation to each object of knowledge, identified on the map as the most homogeneous ones.

4 Application of the methodological framework

The purpose of this section is to present the application of the methodological framework, aiming to provide managers of projects on PDP/PDT on the value chain with knowledge enabling them:

1 to monitor the political, economical/financial and social environment, the regulations/regulatory policy for innovation, judicial aspects and risks that impact directly or not the organisations

2 the best decision as for the contractual negotiation, specially the rights and duties between partners

3 the best choice of partners

4 the best build-up and management of the innovation projects

5 the best definition of the competition policy

6 the definition of tax criteria and the budgetary structure

7 the best definition as for investments

8 the best financial engineering management

9 the definition of the goals to be met

10 the management of shared risks associated to projects

11 to identify the dynamics of technological innovation

12 to monitor on the innovation value chain performance

13 to monitor the innovation policies

14 to monitor the best innovation practice

15 to identify the best situations and environments for innovation

16 to identify the best strategies on the innovation managing

17 to monitor the costs and financial returns, others.

Thus, the data were first extracted from the specialised 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 expert from diverse backgrounds and scenarios, directly and/or indirectly involved with the technology developing process in the innovation value chain in PDP/PDT were identified. As follows, the methodological proceeding proposed applied to the study is described, having the phases:

4.1 Phase 1: Modelling of the information needs on the innovation value chain performance in the PDP/PDT

This phase is structured in three stages:

- *Stage 1:* Determination of the CSF.

- *Stage 2:* Determination of the information areas.
- *Stage 3:* Prioritisation of the information needs starting from the crossing of CSF.

4.2 Phase 2: Determination of the critical knowledge on the innovation value chain performance in the PDP/PDT

This phase has been subdivided as follows:

- *Stage 1:* Identification and acquisition of knowledge.
- *Stage 2:* Determination of the influence stakeholders' knowledge has on the value chain performance in innovation in the PDP under conditions of uncertainty and restraint.
- *Stage 3:* Representation of knowledge.

4.2.1 Phase 1: Modelling of the information needs on the innovation value chain in the PDP/PDT

This phase is structured in three stages:

Stage 1: Determination of the CSF on the innovation value chain in the PDP/PDT

This phase is focused on determining the CSF (Rockart, 1979), and is itself structured in two stages: identification of CSF and evaluation of CSF.

a *Identification:* The identification of CSF is based on the combination of various methods (Bruno and Liedecker, 1984):
  - environmental analysis (external variable: political, economical, legislation, technology, among others)
  - analysis of the industry structure (users' needs, the evolution of the demand, users' satisfaction level, their preferences and needs; technological innovations)
  - meeting with specialists and decision makers
  - the study of literature.

b *CSF evaluation:* After their identification, the CSF is evaluated in order to establish a ranking by relevance. Here the scale model of categorical judgments designed by Thurstone in 1927 has been adopted. Hierarchical structure of CSF is obtained.

Thus, the CSF in PDP/PDT were extracted from the specialised literature and assessed by experts for confirmation. The results showed the following classification: first, the market factor (MK); second, the political (PO); third, the judicial factor (JU); fourth, the technical factor (TE); and fifth, the economical and financial factor (EF) (Table 1).

Table 1 CSF of projects – method of categorical judgment of Thurstone (1927)

Stimulations	C_1	C_2	C_3	C_4	$\mu i = -\sum_{j=1}^{4} Zij \Big/ 4$	*Ranking*
MK	–1.22	–1.22	–0.76	–0.13	–3.76	1
JU	–0.76	–0.13	0.13	0.76	0	3
EF	–0.13	0.43	0.76	3.86	4.92	5
PO	–1.22	–0.76	–0.43	1.22	–1.19	2
TE	–0.76	0.13	0.76	1.22	1.36	4

Stage 2: Determination of the information areas on the innovation value chain in the PDP/PDT

The information areas in PDP/PDT were extracted from the specialised literature and assessed by experts for confirmation. Thus, we first identified the technology development stages:

1 project scope
2 concept development
3 prototype development
4 integration of subsystems
5 prototype production
6 market introduction
7 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:

1 invention
2 project scope
3 concept development
4 technology optimisation
5 technology transfer.

After identifying the technology development stages, the next step was to identify the activities to converge each of the stages in the PDT stages.

The results showed the following knowledge according to the PDT steps:

1 strategic planning of the company
2 technology strategy determination
3 technology
4 consumer

5 generation of ideas

6 project scope development

7 mapping future plans

8 patent survey

9 identifying opportunities

10 identifying potential ideas under certain conditions through preliminary experiments

11 identifying necessary resources and solutions for the shortcomings identified

12 projection of product platforms

13 creation of QFD for technology (technology needs)

14 conducting available benchmarking technology

15 development of partner networks

16 defining new technology functionalities

17 identifying technology impact on the company

18 documents analysis and generation of technology concepts

19 selection and development of the superior technology concept

20 definition of commercial products and processes and possible processes

21 decomposition of system functions into sub-functions

22 definition of system architecture

23 definition of system architecture

24 use of mathematical models that express the ideal function of technology

25 prototype development and testing

26 identification of market impact and manufacture of these possibilities

27 preparation to implement the business case

28 identification and evaluation of critical parameters

29 technology optimisation from its critical parameters

30 analysis of factors that can result in platforms

31 development of the platform subsystems

32 carrying out optimising experiments

33 design of integrated subsystems platform

34 system performance tests

36 defining the technology selection criteria.

Thus, the knowledge on the performance of innovation value chain in PDP/PDT under constraint and uncertainty was based on the activities and their respective technology development stages. After this procedure, information areas are delimited with respect to the different CSFs. The result has allowed defining four groups that represent the areas of information: first, the market area (MK); second, the political area (PO); third, the judicial area (JU); fourth, the technical area (TE); and fifth, the economical and financial area (EF). The goals of the areas of information define specifically what must be achieved by these areas to meet one or more objectives from the projects (business), contributing for the enhancement of the project performance as to quality, productivity and profitability.

Stage 3: Prioritisation of the information needs starting from the crossing of CSF on the innovation value chain in the PDP/PDT

Aiming to know about what area of the project the decision-makers must develop a 'strong management', the prioritisation of the needs of information takes place.

The results shown by the methods compromising programming, Electre III and Promethee II have pointed out the market area as the most relevant one to guarantee the CSF (Table 2).

Table 2 Prioritisation of the information needs starting from the crossing of CSF on the innovation value chain in the PDP/PDT

Information areas	*Ranking*		
	Promethee II	*Compromise programming*	*Electre III*
Market (MK)	1	1	1
Political (PO)	2	2	3
Technical area (TE)	3	3	2
Economical and financial area (EF)	4	4	2

The gathering, analysis and processing of information must be to strongly reinforce the set of activities (market) that form this area, especially in what concerns the information about actions on:

- dynamics of technological innovation
- innovation capability
- opportunities for technology development
- central problems in the management of innovation
- scenarios of technology
- innovation best practice
- success and failure of innovation projects
- strategic planning practices
- best practices of project management

- project portfolio selection
- collaboration in high-technology new product development processes
- resource allocation
- metrics for measuring product development
- competition policy
- best decision as for the contractual negotiation, specially the rights and duties between partners
- client need
- actors
- new technology
- method and technical of project management
- intermediation
- risks
- supplier
- partnerships
- alliances.

4.2.2 Phase 2: Determination of the critical knowledge on the innovation value chain performance in the PDP/PDT

This phase has been subdivided as follows:

Stage 1: The definition of the concept of knowledge on the innovation value chain in the PDP/PDT

This stage determines the concept of knowledge to be taken into account on the development of this work. So, for the operational goals of this work, we have adopted them as the 'contextual information' and the 'theoretical framework and concepts'.

Stage 2: Identification and acquisition of knowledge on the innovation value chain in the PDP/PDT

The result has allowed defining four groups that represent the knowledge: market (MK); the political (PO); the judicial (JU); the technical (TE); and the economical and financial area (EF). After their identification, the knowledge (contextual information and the theoretical framework and concepts) is evaluated in order to establish a ranking by relevance. Here the scale model of categorical judgments designed by Thurstone in 1927 has been adopted. Hierarchical structure of knowledge is obtained.

Table 3 Prioritisation of knowledge on the innovation value chain in the PDP/PDT – context information

Knowledge (stimuli) / *Context information*	C_1	C_2	C_3	C_4	*Total*	*Ranking*
Competitive strategy and market (CSM)	–1.22067	–1.2207	–1.221	–0.7647	–4.43	1
Suppliers and market structure (SMS)	–1.22064	–1.2206	–0.14	1.22064	–1.36	7
Models and methodologies simulating scenarios (MMSS)	–1.22064	0.43073	1.2206	1.22064	1.651	10
Production management and product development, R&D	–0.76471	–0.4307	1.2206	3.86499	3.89	13
Management of innovation projects/best practices for developing technologies (MIDT)	–1.22067	–1.2206	–0.765	1.22064	–1.99	5
Models of technological innovation (MTEI)	–0.76471	0.43073	1.2206	0.76471	1.651	10
Core competencies in developing technologies (CC)	–1.22064	–1.2206	–0.431	1.22064	–1.65	6
Risks of technological innovation projects (RTIP)	–1.22067	–1.2207	–1.221	0.43073	–3.23	3
knowledge engineering and information technology (KE)	–1.22067	–1.2206	0.4307	1.22064	–0.79	8
Performance indicators and metrics of technological innovation (PIMTI)	–1.22067	–0.7647	0.1397	3.86499	2.019	11
Cooperation and strategic alliances (COSAL)	–1.22067	–1.2206	1.2206	3.86499	2.644	12
Strategy and planning for technological innovation (SPTEI)	–1.22067	–1.2206	–0.14	3.86499	1.284	9
Customer demand (CD)	–1.22067	–1.2207	–1.221	–0.1397	–3.8	2
Competition (COM)	–1.22067	–1.2206	–0.765	0.43073	–2.78	4

Table 4 Prioritisation of knowledge on the innovation value chain in the PDP/PDT – theoretical bases

Knowledge (stimuli)	C_1	C_2	C_3	C_4	*Total*	*Ranking*
Theoretical bases						
Theory of knowledge engineering (TKE)	–1.22067	–1.22064	–0.13971	0.431	–2.150292	3
Modeling theory and methods of technological innovation (MTMI)	–1.22064	–0.76471	0.430728	1.221	–0.33398	6
Theory of technology development (TTD)	–1.22064	–0.43073	0.13971	0.14	–1.37195	4
Theories of collaboration and strategic alliances and negotiation (TCSAN)	–0.76471	–0.13971	0.76471	3.865	3.725279	11
Theories of negotiation (TNE)	–1.22067	–1.22064	–0.43073	3.865	0.992949	9
Project management theory of technological innovation (PMTI)	–1.22067	–1.22064	–0.43073	0.431	–2.441312	2
Theory methods and statistical techniques/game theory (TMS)	–0.76471	–0.43073	0.13971	0.765	–0.29102	7
Theory of planning and strategy competitive and market (TPSCM)	–1.22067	–1.22064	–0.43073	–0.14	–3.01175	1
Theory of investment policy (TIP)	–0.76471	–0.43073	0.13971	3.865	2.809259	10
Economic theory/econometrics (ET)	–1.22067	0.13971	0.13971	0.431	–0.510522	5
theories about failures in innovation projects (TFIP)	–1.22067	–0.43073	0.76471	1.221	0.333952	8
Theory about the risks of technological innovation (TRTI)	–1.22064	–1.22064	–1.22064	1.221	–2.441278	2

The achievement method of the research results with the specialists of management of PDP/PDT, with knowledge in Market, revealed their preferences for pairs of stimulation (in the case, the objects of knowledge, and to these submitted the ordinal categories C_1 = fifth place, C_2 = third place and C_3 = fourth place). The evaluation of objects of knowledge (LJC) was done in three stages: In the first stage (1), the frequencies for pairs of stimulations were determined, where Oi is equivalent to objects of knowledge and Oj the specialists.

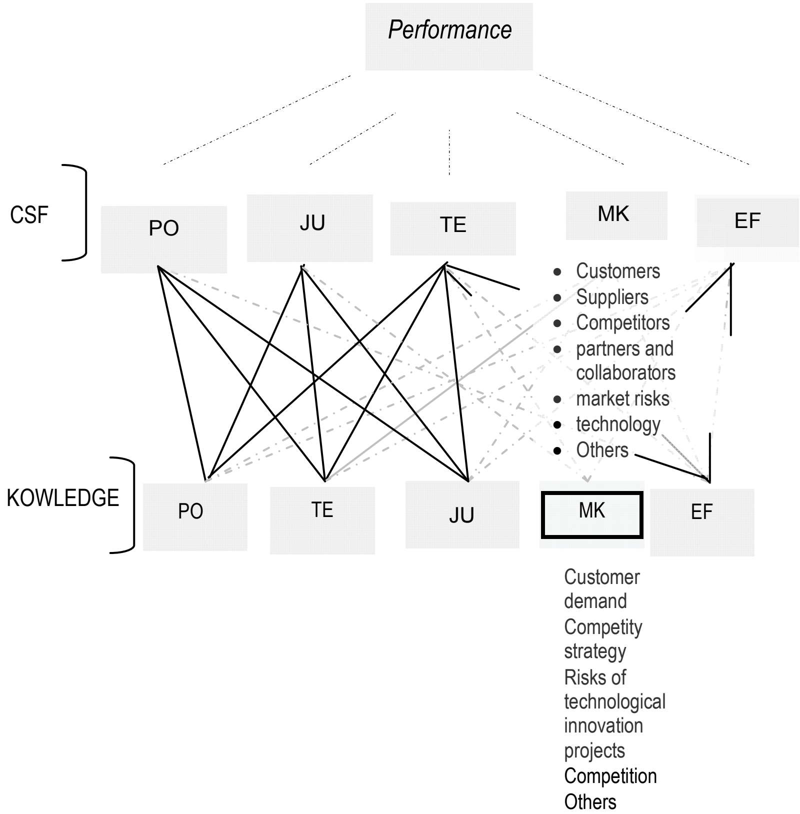
The data was extracted from the preferences of the specialists in relation to the objects of knowledge, attributing weights to the cognitive elements. After that (Stage 2), the preferences of the specialists with relation to stimulations (knowledge) was determined. The results obtained by means of the ordinal frequencies from the results of the previous stage. Finally (stage 3), the accumulated relative frequencies were calculated first. The results obtained here reflect the probabilities of intensity preferences of the specialists in relation to the stimulations (Contextual information and theoretical bases and concepts).

Thus, the knowledge (contextual information and the theoretical framework and concepts) in PDP/PDT were extracted from the specialised literature and assessed by experts for confirmation. The results showed the following classification: first, the market knowledge (MK); second, the political knowledge (PO); third, the judicial knowledge (JU); fourth, the technical knowledge (TE); and fifth, the economical and financial knowledge (EF). In order to demonstrate the application of the methodological proposal, the results of the objects of knowledge (Contextual information and theoretical bases and concepts) on the 'market' were dealt. The results are presented in a growing order of importance (Table 3 and Table 4).

Stage 3: Determination of the influence knowledge has on the value chain performance in innovation in the PDP/PDT under conditions of uncertainty and restraint (CSF)

To execute this step (prioritisation of the knowledge starting from the crossing of CSF on the innovation value chain performance in the PDP/PDT) the multi-criteria method was used (Figure 3): compromise programming, Electre III and Promethe II. The multicriteria method was chosen due to its flexibility for the case in question, especially the subjective nature of the variables involved and the problem to be solved. The methods' application anticipates weight inferences to the evaluation criteria, expressing their relative importance. The relationship of significance between the evaluation criteria should reflect the experts' resulting values within the study's scope of application, considering their specific expectations for each criterion. In this spectrum, defining the criteria weights is characterised as a group decision-making problem, which includes identifying the experts' preferences and consensus.

Figure 3 Determination of the knowledge on the value chain performance in innovation in the PDP/PDT under conditions of uncertainty and restraint – prioritisation of the knowledge starting from the crossing of CSF



The definition of the evaluation criteria weights used in this work proposal was prepared by the experts, through a judgment matrix. With the judgment matrix results these methods were applied: Promethee II, Electre III and compromise programming, to evaluate the knowledge influence on the value chain performance considering of the performance. The results showed the following classification:

Table 5 Knowledge on the value chain performance in innovation in the PDP/PDT under conditions of uncertainty and restraint – compromise programming, Electre III and Promethe II

Stakeholders' knowledge (sources)	*Classification*		
	Promethee II	*Compromise programming*	*Electre III*
Market knowledge (MK)	1	1	1
Political knowledge (PO)/judicial knowledge (JU)	1	1	3
Economical and financial knowledge (EF)	3	3	2
Technical knowledge (TE)	4	4	2

The failed attempts to evaluate the performance of the value chain give way to reinforce the importance of their role, taking a leap towards more innovative and mistake risk-free models. It does not mean replacing an absolute control of the activities and actions, nor forsaking what has worked thus far, rather encouraging pragmatism by emphasising the performance of the value chain in more plausible and feasible ways.

Stage 4: Representation of knowledge

After prioritising the objects of knowledge, the build-up of cognitive maps take place ('market'), assisted by the software *Statistica*. In order to create maps, the denominations of the objects of knowledge have been abbreviated. The results of the decision makers' intensity about the objects of knowledge can be visualised in Figure 4 and Figure 5.

Figure 4 Mental representation of the knowledge in cognitive maps – context mercadology information – business (see online version for colours)

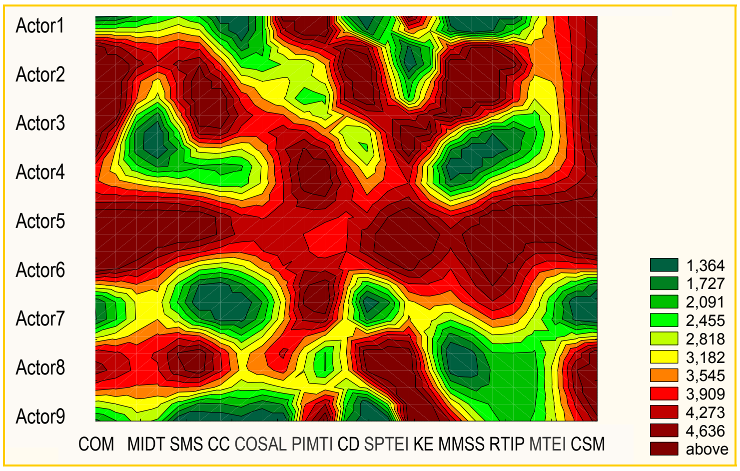
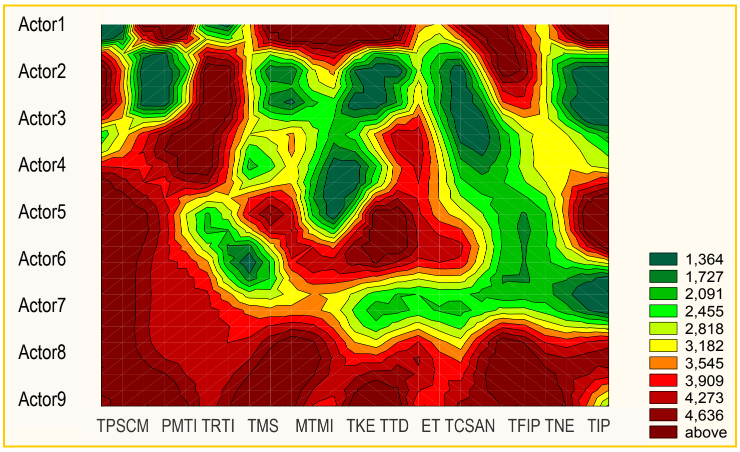


Figure 5 Mental representation of the knowledge in cognitive maps – theoretical bases mercadology – business (see online version for colours)



It is relevant to emphasise the knowledge dimensions about the 'competitive strategy' (CSM) and 'actors' (customer demand and competition). Also recognised is the importance of 'managing of the best practices of the technological innovation management'.

These elements are a priority given that to reach new markets (potential clients, suppliers, competitors, knowledge and new technology, raw materials, innovations and the pursuit for better practices). Moreover, the current market complexity demands that the managing efficacy of product flux surpass the limits from local to global. Within this spectrum, the value chain is viewed as a strategic area that enables companies to expand their relationships in the international market, transposing geographic and economic hurdles. Aiming at an integrated global economy, companies are under pressure to think of products from a global stance and to rationalise their productive processes to maximise corporative resources.

Before anything else, it is worth emphasising that the products development managing is viewed from a strategic perspective, planning and coordinating the necessary activities, in order to meet the desired levels of services and quality at the lowest possible costs. By assembling the vast dimensions of knowledge, there is a prevalence of 'the best managing practices of project of technological innovation' (PMTI); 'planning and strategy competitive and market' (TPSCM); and 'risks of technological innovation' (TRTI). Unified to this there is the know-how of partnerships and alliances, quality and productivity. The challenge that appears in the value chain managing is the result of a good practice:

1 shorten the value flux
2 improve view of the value flux
3 consider value chain managing as a system.

Such practices direct towards planning, managing and control of the value chain operations by means of monitoring the documented performance of the system, which includes:

1 quality levels and the components of costs
2 control strategies that continuously follow the performance and are used to upgrade the process to place it in conformity when it exceeds control patterns
3 control routing that are projected to motivate employees, including additional payment practices for productivity.

Also emphasised is that efficient value chain managing perceives, first of all, allying costs and adequate service levels to clients, assurance of compensatory policies on losses and benefits. With regards to risk management, this work considers as information the methods and organised processes to reduce losses and increase benefits in order to substantiate the strategic objectives. This requires identifying the risks, quantifying risks, selecting risks, decide (avoid or transfer) risks, inform and communicate and follow-up risks completely, exactly, updated and well-timed. With regards to the processes, here are some of the risks:

1 on efficiency
2 innovation risks

3 market risks

4 information risks, and others.

Innovative efforts in new product development should be pursued. This is a complex and difficult business. The reasons for these difficulties are the unexpected risks and their impact, as well as the inability of companies to efficiently defend themselves against these risks. The risks cause instability in product development projects due to unexpected occurrences and the less effective responses taken against them.

4 Contribution

The proposed methodology developed in this work differentiates from other decision support methods, by extracting the tacit knowledge and converting it into explicit knowledge of projects managers in concessions and PDP/PDT. In developing the proposed methodology a number of methods was used, such as the 'critical factors of success', 'multi-objectives methods', 'categorical judgments (scaled) of psychometrics' and 'mental maps' to represent the objects of knowledge, hence establishing a prioritisation. It is underscored that the present approach sought to make the spectrum of decision more intelligent by providing knowledge on the development and management of projects.

With regards to the mercadology conjecture, we have already discoursed and know that for a long time it has been an obstacle for the development and growth of the country. Specifically the product development, one of the most impaired, frequently witnessed discontinuity of innovation projects and relevant programmes. It is also noteworthy that, despite mentioning the market factor as the most representative of that list, a huge list of factors are identified that are essential for conducting a PDP/PDT, there are about 70 factors identified, which were aggregated (clusters: political, economic and financial, marketing, legal and technical). This number contrasts Rockart (1979) and other authors (Stollenwerk, 2001; Thompson and Strickland, 2000), who reported a small number of CSF. As was sometimes referred, the good performance of these CSF results in a successful project.

There were many relevant factors addressed in this research. Initially, there is the application of the 'method of categorical judgments', by which we established from the data collected, a scaling in the preference probabilities of the decision makers, considering that, in general all assessed data showed to be very important from the specialists' view. Using the method, enabled a clear definition of scaling of priorities among the assessed elements. Undoubtedly, the relevance of this method is in the probabilistic nature that it assumes, given the preferences of decision makers at various moments. This fact takes on greater importance when analysing the deciding context in which the projects are, subject to a constant exchange of decision paradigms.

It is within this perspective that our methodological contribution gains emphasis, to the extent that there is support of the critical priorities to be considered in the list of necessary elements for the implementation of a project of this nature. Therefore, our purpose is to contribute to the building of knowledge, as a strategic development for the PDP/PDT. Therefore, through this method, a more pragmatic and efficient direction of the guidelines is sought for its development in the long run, hence ensuring national competitiveness with regard to this category of projects.

5 Final words: lessons learned

Decision-making processes play an important role in product innovation processes. In every stage of the process decisions are made about the progress of the project (Cooper, 1983). The high demand for innovative products has been treated as a challenge for the adoption of traditional project management (PM) practices and methods, specially those ones developed in turbulent and complex business environments. PDP has received special attention from companies due to it is recognised as a source of competitive profits. Continued innovation of products, services, technology and the organisation itself, has been one way to keep a business on its feet during the turbulent 1990s (Cozijnsen et al., 2000). Through its systematisation companies can reduce theirs costs and development time and increase their product quality. The dream scenario for thousands of businesses would be to gain the ability to get their products to market faster, and to know with some certainty that their product-development projects would be completed on schedule. 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.

The present work about process of product development/technology (PDT) on value chain comes to an end, and hopes to have contributed for methodological discussions that need further investigation. Moreover, there is a need to understand value chain regarding social demands that are created within their appropriate social, economic and political context. And evidently many questions remain to be untangled in future studies of this type, specifically of planning in highly complex spectrum of, as the innovation value chain in the PDP/PDT.

The proposed methodology developed in this work differentiates from other decision support methods, by extracting the tacit knowledge and converting it into explicit knowledge of managers in on the innovation value chain in the PDP/PDT. In developing the proposed methodology a number of methods was used, such as the critical factors of success, multi-objectives methods, categorical judgments (scaled) of psychometrics and mental maps to represent the objects of knowledge, hence establishing a prioritisation. It is underscored that the present approach sought to make the spectrum of decision more intelligent by providing knowledge on the development and management of value chain in product development.

Trough this method a more pragmatic and efficient guidance is sought, assisting the guidelines for long-term value chain managing in product/ technology development, hence assuring this segment's competitiveness. Extensive and systematic procedures should be pursued that are capable of uniting the most diverse dimensions of VCM, surpassing the non-scientific practice often pervading some of the works.

In light of KM and its techniques here listed, it was possible to develop a methodology proposal and contribute to the allocation guidelines of resources, to build the in the field of value chain planning. Therefore, it is essential to guide such strategic elements of knowledge. A general introduction to KM and knowledge maps (graphical representations of knowledge objects, bearers, structures, and processes), leads to a list of typical steps to knowledge map development, and a list of typical knowledge map applications. Finally, ideas for the implementation of knowledge VCM.

Within this spectrum, this work investigated the knowledge in the process of product development on the performance of the innovation value chain in PDP applied to technology-based companies. 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. Even if it is simply the probability intensity of the influence of this knowledge on the PDT innovation value chain.

The results obtained have been satisfactory, validating the proceeding proposed for assembling and prioritising critical knowledge for R&D, as well as for comprising other elements of performance in the 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 PDP, 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.

This proposal focuses on highlighting unexplored questions in this complex design. However, it evidently does not intend to be a 'forced' methodology, but intends to render some contribution, even through independent course of actions.

References

Abetti, P.A. (2000) 'Critical success factors for radical technological innovation: a five case study', *Creativity and Innovation Management*, Vol. 9, No. 4, pp.208–221.

Abrahamson, E. (1991) 'Managerial fads and fashions: the diffusion and rejection of innovations', *Academy of Management Review*, Vol. 16, No. 3, pp.586–612.

Amit, R.E.P.J.H. and Schoemaker, P.J.H. (1993) 'Strategic assets and organizational rent', *Strategic Management Journal*, Vol. 14, No. 1, pp.33–46.

Blos, M.F., Quaddus, M., Wee, H.M. and Watanabe, K. (2009) 'Supply chain risk management (SCRM): a case study on the automotive and electronic industries in Brazil', *Supply Chain Management: An International Journal*, Vol. 14, No. 4, pp.247–252

Bruno, A. and Leidecker, J. (1984) 'Identifying and using critical success factors', *Long Range Planning*, Vol. 17, No. 1, pp.23–32.

Buchanan, E.A. (1999) 'An overview of information ethics issues in a world-wide context', *Ethics and Information Technology*, Vol. 1, No. 3, pp.193–201.

Bukowitz, W.R. and Williams, R.L. (2002) *Manual de Gestão do Conhecimento*, Tradução Carlos Alberto Silveira Netto Soares, Porto Alegre.

Calantone, R.J., Vickery, S.K.E. and DröGe, C. (1995) 'Business performance and strategic new product development activities: an empirical investigation', *Journal of Product Innovation Management*, Vol. 12, No. 3, pp.214–223.

Cheng, J., Yeh, C. and Tu, C. (2008) 'Trust and knowledge sharing in green supply chains', *Supply Chain Management: An International Journal*, Vol. 13, No. 4, pp.283–295.

Chesbrough, H. and Rosenbloom, R.S. (2002) *The Role of the Business Model in Capturing Value from Innovation: Evidence from Xerox Corporation's Technology Spin Off Companies*, Vol. 11, pp.529–555, Oxford University Press, Industrial and Corporate Change.

Christensen, C.M. and Raynor, M. (2003) *The Innovator's Solution: Creating and Sustaining Successful Growth*, Harvard Business School Press, Boston, MA.

Cooper, R.G. (1983) 'A process model for industrial new product development', *IEEE Transactions on Engineering Management*, Vol. 30, No. 1, pp.2–11.

Cooper, R.G. (1993) *Winning at New Products: Accelerating the Process from Idea to Launch*, Addison-Wesley, New York.

Cozijnsen, A.J., Vrakking, W.J. and Van Ijzerloo, M. (2000) 'Success and failure of 50 innovation projects in Dutch companies', *European Journal of Innovation Management*, Vol. 3, No. 3, pp.150–159.

Damanpour, F. (1991) 'Organizational innovation: a meta-analysis of effects of determinants and moderators', *Academy of Management Journal*, Vol. 34, No. 3, pp.555–590.

Davenport, T. and Prusak, L. (1998) *Conhecimento empresarial*, Campus, Rio de Janeiro.

Dosi, G. (1982) 'Technological paradigms and technological trajectories', *Research Policy*, Vol. 11, No. 3, pp.147–162.

Fawcett, S.E., Allred, C., Magnan, G.M. and Ogden, J. (2009) 'Benchmarking the viability of SCM for entrepreneurial business model design', *Benchmarking: An International Journal*, Vol. 16, No. 1, pp.5–29.

Feenstra, R.C. (1998) 'Integration of trade and disintegration of production in the global economy', *Journal of Economic Perspectives*, Vol. 12, No. 4, pp.31–50, American Economic Association.

Fletcher, L. and Polychronakis, Y.E. (2007) 'Capturing knowledge management in the supply chain', *EuroMed Journal of Business*, Vol. 2, No. 2, pp.191–207.

Godsell, J., Birtwistle, A. and Hoek, R.V. (2010) 'Building the supply chain to enable business alignment: lessons from British American Tobacco (BAT)', *Supply Chain Management: An International Journal*, Vol. 15, No. 1, pp.10–15.

Griliches, Z. (1979) 'Issues in assessing the contribution of R&D to productivity growth', *Bell Journal of Economics*, Vol. 10, No. 1, pp.92–116.

Griliches, Z. (1990) 'Patent statistics as economic indicators: a survey', *Journal of Economic Literature*, Vol. 28, No. 4, pp.1661–1707.

Halldórsson, Á., Kotzab, H., Mikkola, J.H. and Skjøtt-Larsen, T. (2007) 'Complementary theories to supply chain management', *Supply Chain Management: An International Journal*, Vol. 12, No. 4, pp.284–296.

Hamel, G.E. and Prahalad, C.K. (1994) *Competing for the Future*, Harvard Business School Press, Boston, MA.

Hanisch, B. et al. (2009) 'Knowledge management in project environments', *Journal of Knowledge Management*, Vol. 13, No. 4, pp.148–160.

Hoffman, K.P. et al. (1998) 'Small firms, R&D, technology, and innovation in the UK: a literature review', *Technovation*, Vol. 18, No. 1, pp.39–55.

Johannessen, J.A. (2008) 'Organisational innovation as part of knowledge management', *International Journal of Information Management*, October, Vol. 28, No. 5, pp.403–412.

Johannessen, J.A., Olsen, B. and Lumpkin, G.T. (2001) 'Innovation as newness: what is new, how new, and new to whom?', *European Journal of Innovation Management*, Vol. 4, No. 1, pp.20–31.

Kannabiran, G. (2009) 'Process and content dimensions of knowledge management strategy planning: an exploratory study', *International Journal of Knowledge Management Studies*, Vol. 3, Nos. 1–2, pp.79–96.

Kannan, G. and Aulbur, W.G. (2004) 'Intellectual capital: measurement effectiveness', *Journal of Intellectual Capital*, Vol. 5, No. 3, pp.389–413.

Kayakutlu, G. and Büyüközkan, G. (2010) 'Effective supply value chain based on competence success', *Supply Chain Management: An International Journal*, Vol. 15, No. 2, pp.129–138.

Kim, S.W. (2006) 'The effect of supply chain integration on the alignment between corporate competitive capability and supply chain operational capability', *International Journal of Operations & Production Management*, Vol. 26, No. 10, pp.1084–1107.

Kotabe, M. and Swan, K.S. (1995) 'The role of strategic alliances in high technology new product development', *Strategic Management Journal*, Vol. 16, No. 8, pp.621–636.

Liebeskind, J.P. (1996) 'Knowledge, strategy, and the theory of the firm', *Strategic Management Journal*, Winter Special Issue, Vol. 17, pp.93–107, John Wiley & Sons.

Moresi, E.A.D. (2001) 'Inteligência organizacional: um referencial integrado', *Ci. Inf.*, May/August, Vol. 30, No. 2, p.35, Brasília.

Mouritsen, J., Bukh, P.N. and Marr, B. (2004) 'Reporting on intellectual capital: why, what and how?', *Measuring Business Excellence*, Vol. 8, No. 1, pp.46–54.

Nelson, R. and Winter, S. (1982) *An Evolutionary Theory of Economic Change*, Harvard University Press, Cambridge, Mass.

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

Pavitt, K. (1984) 'Sectoral patterns of technical change: towards a taxonomy and a theory', *Research Policy*, Vol. 13, No. 6, pp.343–373.

Power, D. (2005) 'Supply chain management integration and implementation: a literature review', *Supply Chain Management: An International Journal*, Vol. 10, No. 4, pp.252–263.

Probst, G., Raub, S. and Romhardt, K. (2002) *Gestão do Conhecimento: os elementos construtivos do sucesso*, Bookman, Porto Alegre.

Rockart, J.F. (1979) 'Chief executives define their own data needs', *Harvard Business Review*, Vol. 57, No. 2, pp.81–93, Harvard Business School Publication Corp.

Ropera, S., Dub, J., James, H. and Love, J.H. (2008) 'Modelling the innovation value chain', *Research Policy*, Vol. 37, Nos. 6–7, pp.961–977.

Rosenberg, N. (1976) *Perspectives on Technology*, Cambridge University Press, Cambridge and New York.

Santos, F.M. and Eisenhardt, K.M. (2005) 'Constructing markets and organizing boundaries: entrepreneurial actions in nascent fields', Unpublished manuscript, Seattle.

Schumpeter, J.A. (1934) *The Theory of Economic Development*, Harvard Univ. Press, Cambridge, MA.

Souza, J. (1988) *Métodos de Escalagem Psicossocial*, Vol. V, Thesaurus, Brasília.

Stollenwerk, M.F.L. (2001) 'Gestão do Conhecimento: Conceitos e Modelos', in Tarapanoff, K. (Ed.): *Inteligência Organizacional e Competitiva*, capitulo 5, Editora UnB, Brasília.

Svensson, G. (2007) 'Aspects of sustainable supply chain management (SSCM): conceptual framework and empirical example', *Supply Chain Management: An International Journal*, Vol. 12, No. 4, pp.262–266.

Teece, D.J. (1986) 'Profiting from technological innovation', *Research Policy*, Vol. 15, No. 6, pp.285–305.

Teece, D.J., Pisano, G. and Shuen, A. (1997) 'Dynamic capabilities and strategic management', *Strategic Management Journal*, Vol. 18, No. 7, pp.509–533.

Thiel, E.E. (2002) 'Proposta de modelo de implantação de um projeto de gestão do conhecimento com base em processos organizacionais', Thesis Production Engineer, University Santa Catarina.

Thompson, A. and Strickland, J. (2000) *Planejamento estratégico: elaboração, implementação e execução*, Pioneira, São Paulo.

Thurstone, L.L. (1927) 'A law of comparative judgment', *Psychological Review*, Vol. 37, pp.273–286.

Tidd, J., Bessant, J. and Pavitt, K. (1997) *Managing Innovation Integrating Technological, Market and Organizational Change*, John Wiley & Sons, New York.

Tushman, M.L. and O'Reilly, C.A. (1997) *Winning Through Innovation: A Practical Guide to Leading Organizational Change and Renewal*, Harvard Business School Press, Boston, Mass.

Unahabhokha, C., Platts, K. and Hua Tan, K. (2007) 'Predictive performance measurement system: a fuzzy expert system approach', *Benchmarking: An International Journal*, Vol. 14, No. 1, pp.77–79.

Wheelwright, S. and Clark, K. (1992) *Revolutionising Product Development*, New York, Free Press.

Winter, S.G. (1987) 'Knowledge and competence as strategic assets', in Teece, D.J. (Eds.): *The Competitive Challenge: Strategies for Industrial Innovation and Renewal*, pp.159–84, Ballinger, Cambridge, MA.