Multi-Model Standard Reference for Strategies in Prospecting of Knowledge in Innovation Value Chain: Towards Product Development Process

Selma Regina Martins Oliveira
Programming Computer Modeling & System
University F. Tocantins – Brazil

Jorge Lino Alves
INEGI, Faculty of Engineering
University of Porto - Portugal

Abstract

This work intends to contribute to the planning policy guidelines in the field of innovation value chain in the product development process. Thus, it develops a multi-model proposal to determine strategies in prospecting of knowledge that considers a sequence of systematic procedures in the following phases: 1) Mathematical modeling; and 2) verification of the mathematical model. This research treated Brazil's high-tech industries as the empirical targets and the research work was done with the participation of experts with technical and scientific knowledge about the research object. Several support tools were used to formulate the modeling in order to reduce subjectivity in the results: psychometric scaling – Thurstone's Law of Categorical Judgments (LCJ), Multicriteria Analysis-Compromise Programming, Electre III and Promethee II, and Neurofuzzy Technology. The mains results obtained demonstrated that.

Keywords: Multi-Model Standard Reference; Planning; Prospecting of Knowledge; Innovation Value Chain.

1. *Introduction*

Recently, relevant changes have made organizational boundaries more fluid and dynamic in response to the rapid pace of knowledge diffusion (Abrahamson, 1991; Griliches, 1990; Teece, 1986), and innovation and international competition (Chesbrough and Rosenbloom, 2002; Christensen, 2003; Damanpour, 1996). This helps to reconsider how to succeed with innovation (Teece et. al., 1997; Tidd et.al., 1997; Teece, 1986; Martin, Horne, Schultz, 1999; Wheelwright and Clark, 1992). Thus, innovative companies make use of their capabilities to appropriate the economic value generated from their knowledge and innovations (Griliches, 1990; Teece, 1986). Therefore, the supply of innovative products is presented as a quality standard in the race for pressing demands.

It is true that a new product or process can represent the end of a series of knowledge initiatives and the beginning of a process of value creation, which, under conditions imposed by various parties, can produce efficient results in the global performance of the value chain, reaching not only businesses that innovate, but also correlated companies (Klette et. al., 2000; Beugelsdijck and Cornet, 2001). Knowledge can lead to performance improvements of other co-related or co-located companies (Klette et al, 2000). Moreover, innovations are the incremental results produced by the interaction process of the knowledge generated, disseminated and applied to the various links in the value chain (Camagni, 1991; Bottazzi and Peri, 2003; Powell and Grodal, 2005), in which the first link of the innovation value chain is the knowledge derived from the companies' various sources. The second link of the innovation chain value is the transformation of knowledge into product and process. The final link in the innovation value chain is the knowledge that is exploited. This is the process by which business performance is influenced by innovation (Geroski et al., 1993). It is the utilization of products by the companies – and the main focus is business return and growth. Of course knowledge goes beyond the company's boundaries and links in the value chain and influences the results of the value chain.

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. The characteristics of the value chain differ a great deal, therefore becoming the object of analysis equally differentiated.

Many times the projects are made impracticable still in the act of planning, hence becoming unsustainable. One of the aspects that deserve 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. Traditionally, the planning phase "sins" when it is elaborated without support of methods and adequate techniques having prioritized the knowledge that really is essential in the management of the value chain. In this spectrum, the perspective of the efficiency of the value chain Management should be standardized in methods and techniques which permit a correct planning and management upon the decisions to be made.

Thus, this work intends to contribute to the planning policy guidelines in the field of innovation value chain in the PDP. Thus, it develops a multi-model proposal to determine Strategies in Prospecting of knowledge, that considers a sequence of systematic procedures in the following phases: 1) Mathematical modeling; and 2) verification of the mathematical model. This work is systematized in the following sections: 1 –Mathematical modeling; 2 – Method to verify the model; and lastly, the conclusions and implications.

2. Modeling Mathematical

This section presents the procedures to develop the model. The proposal is structured in two phases: model construction and verification. The proposed model represents a set of variables and procedures systematized in decision-making, based on the CSF, knowledge and strategies of the innovation value chain and its guiding elements. The model design entails the following steps:

i. Formulate the theory or hypothesis, which guides the mathematical model.
ii. Specify the mathematical model of the theory ($Y = ß_1 + ß_2X + ß_3X_2 + ụi$)
iii. Obtain data to find the numerical values for $ß_1$ and $ß_2$
iv. Estimate the model parameters by means of regression analysis.
v. Test the hypothesis to see whether the estimates satisfy the expectations of the theory being tested.
vi. Provide forecasts or predictions, because if the chosen model confirms the hypothesis or theory under consideration, it can be used to predict future values of the dependent variable (or prediction) Y, or predict, based on known or expected future values of the explanatory variable (or predictor).
vii. Use the model for policy planning in innovation value chain/network of knowledge.

The following describes the theoretical assumptions to design the model. The application of all the preceding steps is undertaken.

2.1 *Theoretical Assumptions to Generate the Model*

The model structure is guided by theoretical assumptions and is primarily based on the assumptions of national and international experiences in the innovation value chain in PDP. This research treated Brazil’s high-tech industries as the empirical targets. Thus, the following assumptions are presented:

i. The PDP in innovation value chain can be seen as a problem that is classified as a high complexity spectrum, it contains several elements and interrelated parts and observed under different aspects, which significantly influence the knowledge of the actors in the PDP multidisciplinary teams, which requires an integrated, threaded, interactive and collaborative model between the parties.
ii. The characteristics of the flaws in the innovation value chain in the PDP should be considered in the design of new products in the innovation value chain. Failures such as: (iii) use of inappropriate management models; (ii) use of inappropriate cost-effective models; (iii) adopt inappropriate approaches to use technologies. Overemphasis on technology, rather than focus on objectives to be achieved; (iv) oversight of not considering the actors’ knowledge (suppliers, customers, competitors, universities, etc.) that is effective in the value chain in the technologies development of projects; (v) technology development projects implemented without adequate planning and using “ready packages” without a feasibility study, among others. Here are some flaws related to: “design”, development and project implementation process, policy and/or overall strategy, micro and macro design of the system and subsystems, logistics and evaluation, not feasible deadlines and targets, productive capacity and inadequate resources, distinction between products and technologies; cycle time, lead-time, multidisciplinary teams’ knowledge, innovation impact, among others.

iii. The actors' knowledge in the multidisciplinary teams determines the strategies in PDP and helps identify the value chain innovation potential (knowledge networks).

iv. The environment's configuration characteristics (individual preferences directly influence individual decisions for technologies in the innovation value chain. The interrelation changes the individual decisions that affect the value chain system. Redefining the structure of the market dynamics, especially customer profile, behavior through the values and roles of individuals brings about a new consumption pattern, which requires offering quality products, production capacity efficiency and speed in launching new products. Therefore, product demand changes in the innovation value chain may be different than it was before, due to changes in society. In this spectrum, new methods and techniques are presented at this time for the PDP.

v. The analysis of quality product demand has undergone a major paradigm shift, from the product-based approach (linear) to an approach based on products with added value (innovation). That is, the existing knowledge added to new knowledge. Two dimensions began to be emphasized in the companies' field of activity: (i) technology development considering cost, quality, productivity and flexibility; (ii) development as a way to secure existing customers, new customers, to minimize the effects of costs and income generation. The conventional modeling of technology development deals with unconnected events (sequential), while the approach based on knowledge/value chain focuses on the dynamics related to the behavior of the individual/multidisciplinary teams with autonomy, flexibility, independence, collaboration and cooperation, following their own pace. That is, an integrated approach through the actors' knowledge (partners) to achieve new technologies given simultaneous engineering.

vi. The financial and economic, political, social and market configuration directly influences individual decisions in choosing a product. The interrelationship of these components affects the value chain innovation on the performance of PDP.

vii. The prospecting of knowledge in the PDP in innovation value chain is based on the CSF of the desired reference by the multidisciplinary team members, and therefore influences the definition and redefinition of strategies in the PDP innovation value chain/knowledge networks.

viii. The cultural characteristics of PDP multidisciplinary teams directly influence strategies on the PDP innovation value chain. The interrelationship modifies the decisions that affect the performance of the PDP value chain innovation.

ix. The determinants that motivate customers to search for innovative products cannot be reduced to simple cost measures, there are other factors, such as: flexibility, quality, satisfaction, among others.

x. The inclusion of strategic variables changes the statistical significance of modeling. Redefining the knowledge dynamics structure, particularly concerning the demand for differentiated products, behavior through values and the roles of customers bring a new standard of knowledge and changes in the demand for new products, which may be different than it was before, due to changes in society. And therefore, new strategies that allow adapting the knowledge of the actors/multidisciplinary teams in PDP.

xi. Given that a system represents several objectives to meet the needs related to individuals/members of the PDP multidisciplinary teams, these can be grouped into categories/teams and described in terms of where, when and how far from each other.

xii. The knowledge-based approach requires flexible strategies, and at the same time, the interaction between actors/members of the PDP multidisciplinary teams, and between them and other actors. The inclusion of strategic variables then enables analyzing the performance of the PDP actors' space-temporal knowledge (prior and post).

xiii. The knowledge-based model requires a flexible, cooperative, interactive and dynamic structure of the actors/members of the PDP multidisciplinary teams in the knowledge network, to promote the individuals' learning at their own space-time pace, to favor autonomy and independence and also the interaction and sharing of knowledge. Of course, technology is the determining factor as an instrument that enables the interaction between actors and resources, at any moment and combination. Participation in networks implies a new knowledge development/construction process.

xiv. Consequently, the model system of PDP knowledge/value chain networks should include flexible strategies according to the individual characteristics of the PDP actors/members of multidisciplinary teams in the innovation value chain. The networks must have flexible and rhythmic structures, established by horizontal, interrelated and dynamic relationships that assume collaborative and interactive work, providing the knowledge construction for the PDP actors/ multidisciplinary team members.

2.2 *Basic Elements for the Model Design.*

In this section the model is designed with the following definitions:

i. Strategy standards in the prospecting of innovation value chain (knowledge network): The analysis of strategy standards can be seen as a classification problem where the input is a set of elements that includes strategies and the output is the classification of these elements within a set of “natural” or “predetermined” categories. In the model, the strategy standards **(Ss)** comprises a set of categories, in which the beginning and end of the chain are predetermined when PDP starts, and ends when the PDP concludes, which presupposes knowledge prospecting. The strategy standards **(Ss)** classification can be represented according to the purpose of the main goal of the multidisciplinary teams in the innovation value chain in PDP.

ii. Knowledge standards to define strategies: The analysis of strategy standards can be seen as a classification problem, in which the input is a set of knowledge and the output is the classification of such knowledge within a set of natural or predetermined categories. In the model, the knowledge standards will be comprised of a set of categories, in which the beginning and end of the chain are predetermined at the end of the PDP. Knowledge can be classified into two groups: Theoretical Bases + Information Concepts **(TB + IC)**. The “+” represents the construction time increase of knowledge during the PDP .

iii. Knowledge network standards (innovation value chain): The analysis of knowledge network standards can be seen as a classification problem, in which the input is a set of measures that defines the knowledge network standard strategies, which results from evaluating the degree of previous and post individual knowledge for the PDP, generated from the CSF. And the output is the performance of these strategies in a set of natural or predetermined categories. In the model, the knowledge network standards will consist of a set of categories, in which the beginning and end of the chain are pre-determined before and after the PDP. The purpose of the strategies can be classified according to the Theoretical Bases and Information Concepts. The “+”represents the addition of at least one additional knowledge in response to the impact of the strategies.

iv. Connecting the strategies: the reproduction and representation of the behavior of the strategies according to the standard **(N).**

v. Characteristics of the context (C), individuals (I), motivations (M) in space-time: Thist is the context with its economic, social, political, market; the individuals with their different needs and motivations and cultural values, in a space-time to encourage the individual for innovative technologies.

vi. Connecting the strategies (S) according to the knowledge standards (S): the strategy-based approach places emphasis on standards and on the behavior dynamics of individual knowledge in PDP. The standard is set by the dynamic modeling Ω and its interrelation with the behavioral characteristics of the individuals and the dependence relationship of real individual knowledge (IK) in relation to the prospected/desired knowledge (DK), i.e., *ƒ* (IK/DK), as follows:

$$S(S) = \Omega\, \{IK,\, f\ (IK / DK)\}$$

vii.The Network Standard according to connecting the strategies: the network-based approach places emphasis on standards and on the dynamics of the strategies to construct knowledge of the actors (individual) and multidisciplinary teams (individuais). The standard is defined by the dynamic modeling **Ω** and its interrelation with the characteristics of the strategies and the dependence relationship of individual knowledge (IK) in relation to the prospected/desired knowledge (DK), i.e., *ƒ* (IK/DK), as follows:

$$S(N) = \Omega\, \{S,\, f\ (IK / DK)\}$$

viii. Learning characteristics (knowledge acquisition) of individuals in the network (environment) in space-time (A): To add the learning characteristics (knowledge acquisition) in space-time and represent the network, the State term is created, defined as the set of environmental conditions (network-value chain), where the individuals and their characteristics are placed, at certain times. These states range from inception to completion (*State 1, State 2,..., State N, State N + 1*) of the product development process in the innovation value chain. For an individual **I,** beginning a development process of any product *(State 1)* with learning 1, towards any learning 2 *(State 2)*, there will be a Period of Time **PT** that begins and ends the product development process, a time **T,** a mode **M**, Types of activities **TA**, in the network **N,** which has the addition of knowledge **K**, which motivates the individual.

ix. Characteristics of knowledge prospecting of individuals in space-time: To form (add) knowledge in space-time, the term State is created, defined as the set of environmental conditions (network) in which the individuals and their characteristics are placed, at certain times. These states range from the beginning of the product development process to its completion *(State 1, State 2, ..., State N, State N + 1)*. For an individual **I,** beginning any module or stage *(State 1)* with knowledge 1, toward any knowledge 2 *(State 2)*, there will be a time period **PT** that begins and ends the program, a time **T,** a mode **M,** Types of activities **TA,** in the network **N,** in which there is the addition of knowledge **K,** which motivates the individual.

x. Implementation of activities in space-time (ST): For an individual's given motivation, various states must be covered *(State 1, ..., State N)* over time, until knowledge is constructed during PDP. In each state the individual selects a set of activities to be developed, as well as the time required to perform such planned activities. The individual structure (technical and human), such as access to technology, the pace of learning, the experiences, opportunities and constraints are some factors that determine the feasibility of the strategies and consequently, the performance and dynamics of the network (innovation value chain).

xi. Measures of the dependency level of individuals in relation to the value chain (system): The measure of dependency of individuals **(DI)** in relation to the system **(DS), *f* (DI/DS)** will be defined, among others, by the characteristics of the innovation value chain (Knowledge Network).

xii. The characteristics of the W and its components directly influence the training planning decisions in the innovation value chain in PDP. The interrelationship of factors affects the decisions that affect the performance of the innovation value chain in the PDP.

xiii. Individual knowledge: In the knowledge network-based approach (value chain), the individual knowledge **(IK)** is identified and analyzed from the critical success factors (**W**). From this foundation, the degree of evaluation of the individuals' real **(DRKE)** and prospected/desired **(DDKE)** knowledge are represented, before and after **(DRKE)** the product development process. Individual knowledge is the dimensions that invigorate the selection of strategies, according to the degree of intensity, therefore they should be considered as a strategic element in the planning strategies of the knowledge network (value chain).

xiv. Strategies according to knowledge: As a hierarchical problem, the strategies **(S)** are defined using the discrepancy from the evaluation of the degree of knowledge (DKE), before and after the product development process, in which the inputs are the real knowledge and the output is the level of performance classification of the knowledge prospected/acquired (desired) given the strategies used during PDP. There is an inter-connection between the strategies that can be defined by the dependency relationship of real individual knowledge **(IK)** and the desired knowledge **(DK).** If the individual knowledge and desired knowledge are defined in terms of critical success factors, expressed as:

$$IK \text{ is } f\,(W_n)$$
$$DK \text{ is } f\,(W_n)$$

And if the relationship between the individual and desired knowledge leads to evaluating the degree of knowledge, expressed by:

$$(IK/DK) = DKE$$

Then, it follows that:

$$DKE\,(IK/DK) \text{ is } f\,(W_n)$$

xv. Dynamic behavior: Modeling the dynamic behavior of the knowledge network = Ω {Individuals (I) and the interactions between the qualitative dimensions in space-time will be represented by a dynamic modeling function **Ω ,** which will enable to realistically express the dynamic inter-relationships observed in the individual decisions that affect the innovation value chain. Thus, the Individual **(I),** The Critical Success Factors **(W),** knowledge **(K)** and Strategies **(S)** are set. Thus, the dynamic behavior of the knowledge network (innovation value chain) **Ω** of the modeling would be defined by the following elements:

$$N = \Omega\,\{ \text{Individuals } (I), \text{Critical Success Factors } (W), \text{knowledge } (K), \text{Strategies } (S)\}$$

Modeling Constraints:

(I) *Recursion:* The conditions of the previous state "State (N)" influence the following state "State (N+1)".

(II) *(Linearity:* the conditions of the following State "State (N +1)" are not influenced by the previous state "State (N)".

(III) *Simultaneity in the formation of knowledge:* knowledge construction does not follow a standard exclusion, that is, the formation of the theoretical bases and concepts and context information (knowledge) can happen simultaneously. *(IV)Temporal Continuity:* represents the time limit before and after the PDP in the construction of individual knowledge.

2.3 Formulating the architecture of strategies in the knowledge network model

The role of dynamic modeling that can represent the knowledge network is **Ω,** establishing the relationship between the different elements that affect the network through the following relationship: **Ŕ= Ω {**Critical Success Factors (**W**), knowledge (**K**), Strategies (**S**)**}.** The knowledge network as a function of the dimensions (critical success factors, knowledge and strategies) is defined by the dynamic modeling function **Ω** and its interrelation with the characteristics of the W of the value chain PDP//individual, and the dependency relationship of individual knowledge in relation to prospected/desired knowledge, i.e., ***f*** **(IK/DK)**, and individual knowledge regarding the strategies ***f*** **(IK/**S**),** as follows: where the dynamic modeling function is represented by the following relationship

$$S_n = \{(IK/DK),\ f\ W_n)\ \} \qquad (1.1)$$

Considering that: **IK** by TB=theoretical bases and concepts and CI=context information, we have: **IK=TBCI**

$$If,\ N = \Omega\ f\ (S_n), \qquad (1.2)$$

Then, we have from this formulation and from the objectives proposed in this article, the model that will reproduce the dynamics of the knowledge network strategies, expressed by:

$$N = \Omega\ f\{((TBCI_I/TBCI_D),\ f(W_n))\ \} \qquad (1.3)$$

And if the variation in the degree of knowledge evaluation **(ΔDKE)** is the result of the relationship between individual knowledge for desired knowledge ($TBCI_I/TBCI_{\mathbf{D}}$**)**, then:

$$N\ = \Omega\ f\{((\Delta DKE),\ f(W_n))\} \qquad (1.4)$$

Where **N** will be represented by the dynamics of the knowledge network strategies. And the dependency relationship of TBCI knowledge for the strategies defined, among others, by the innovation value chain characteristics in the product development process. Also assuming that the functional relationship between the variables is linear. And that the dependency variable is linearly related with the explanatory variables, the following $ß_1, ß_2$ and $ß_3$ parameters are added to equation 1.5:

$$N' = ß_1 + \Omega\ f\{((ß_2\Delta DKE),\ f(ß_3W_n))\ \} \qquad (1.5)$$

Where: $ß_1, ß_2$ and $ß_3$ are the model parameters (statistical sample). In that $ß_1$ is the intercept and $ß_2$ and $ß_3$ are the slope coefficients – called linear regression coefficients. The accuracy of the linear estimators is prepared by the OLS (Ordinary Least Square) method. Considering that the relationships between variables are inaccurate, the variable **u** is added to the model (stochastic random variable), expressed as follows: (1.6):

$$N' = ß_1 + \Omega\ f\{((\ ß_2\Delta DKE),\ f(ß_3W_n)) + u_i\ \} \qquad (1.6)$$

Substituting DKE for X_1, and Wn for X_2 for the purposes of terminology adjustment in the model, we have (1.7):

$$N' = ß_1 + \Omega\ f\{((\ ß_2\Delta X_1),\ f(ß_3X_2)) + u_i\ \} \qquad (1.7)$$

Where **u** is the sum of all variables that affect the model, but which are not explicitly considered. The disturbance term u is a substitute of all explanatory variables *X* omitted from the model, but which collectively affect *y*.

3. Multi-Method to Verify the Model

The current proposal to build up a methodological support applied to the value chain management happens within the following proceedings: *Phase 1:Modeling the Information Needs; Phase 2: Modeling Knowledge; Phase 3: Determining Degree of Knowledge Evaluation; Phase 4: Modeling the Network Strategies.* Next, the detail of the phases and steps.

Phase 1: Modeling the Information Needs - CSFs :This phase is subdivided into: Determination of the *CSFs and determination of the information areas.*

The identification of CSF is based on the combination of various methods (Leidecker and Bruno,1984): environmental analysis ; analysis of the industry structure; meeting with specialists; and the study of literature.

After their identification, the CSF are evaluated in order to establish a ranking by relevance. Here the scale model of categorical judgments designed by Thurstone in 1927 has been adopted.

Thus, the evaluation of the CFS is systematized in the following steps: Step 1: determination of the frequencies by pairs of stimuli. Step 2: determination of the frequencies of ordinal categories. Step 3: calculation of the matrix [πij] of the relative frequencies accumulated. Assembling here the many dimensions of the CFSs,

the results show that there are: first, the Market factor; second, the Political factor; third, the Economical and financial factor; fourth, the Technical factor. The CSF having already been defined, information areas are delimited with respect to the different CSF. 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: Compromise Programming ™, Promethee II ™ and Electre III ™. These methods rendered their contributions in determining the performance in the areas of information, which led to the identification of "Market Area" as the most important ones in order to globally ensure the overall critical success factors. The critical knowledge for value chain management is determined in the sequence.
Phase 2 Modeling Knowledge on Value Chain: This phase has been subdivided as follows: This phase has been subdivided as follows: *stage 1 - identification and acquisition(prospecting) of knowledge; and stage 2 - evaluation of knowledge.* This proceeding is shown in details as to its structure.

Stage 1: Identification and Acquisition/prospecting of Knowledge. Initially, information topics which have been already identified will be elaborated, analyzed and evaluated in order to be understood by the decision makers during the formulation and the management of a PDP. Following this, they will be reviewed and organized 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, 2002), 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 PDP. First the information is gathered. Then the combination and internalization is established by the explicit knowledge (information) so that it can be better understood and synthesized 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 analyzed 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 (Célis, 2000). 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, where the concept and the theory on which is based the performance of the actions (articulations) developed in those areas that allow to guarantee the feasibility of the projects on value chain management are identified. In other words, which knowledge and theory are required to be known in order to ensure the success of projects on value chain management in that area. Then, the analysis of surveys in public and private institutions about the job market for these institutions takes place bearing in mind the demands of similar areas studied in this work.

As for the offer, we intend to search for the level of knowledge required by the companies and other organizations in those areas, as well as what concerns technical improvement (means) for the professionals. 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". After being identified and acquired, the knowledge is evaluated, with the aid of the Method of Categorical Judgments of Thurstone (1927). The results show that there are: first, the Market Knowledge; second, the Political Knowledge; third, the Economical and financial Knowledge; fourth, the Technical Knowledge. In order to demonstrate the application of the modeling, the results of the objects of knowledge on the Market Knowledge were dealt.

Table 1: Knowledge Marketing/Business

Theoretical Bases and Concepts and Context Information – Market Business						
KNOWLEDGE (STIMULIS)	C1	C2	C3	C4	TOTAL	Ranking
Project management of technology	-1,22067	-1,2207	-1,221	-0,7647	-4,43	1º
Engineering knowledge and information technology	-1,22064	-1,2206	-0,14	1,22064	-1,36	7º
Suppliers of products and technologies	-1,22064	0,43073	1,2206	1,22064	1,651	10º
Modeling	-0,76471	-0,4307	1,2206	3,86499	3,89	13º
Economy	-1,22067	-1,2206	-0,765	1,22064	-1,99	5º
Teory Policy	-0,76471	0,43073	1,2206	0,76471	1,651	10º
Partnerships and alliances	-1,22064	-1,2206	-0,431	1,22064	-1,65	6º
Demand for products and technologies	-1,22067	-1,2207	-1,221	0,43073	-3,23	3º
Competitive strategy	-1,22067	-1,2206	0,4307	1,22064	-0,79	8º
Organizational structure of technological projects	-1,22067	-0,7647	0,1397	3,86499	2,019	11º
Institutionalization of technological projects	-1,22067	-1,2206	1,2206	3,86499	2,644	12º
Planning and technologies management	-1,22067	-1,2206	-0,14	3,86499	1,284	9º
Risks in projects of technologies	-1,22067	-1,2207	-1,221	-0,1397	-3,8	2º
Quality and productivity in technological projects	-1,22067	-1,2206	-0,765	0,43073	-2,78	4º

Table 2: Public Policies Government Management Knowledge

Theoretical Bases and Concepts and Context Information Public Policies Government Management (PPGM)						
Knowledge (Stimulis)	C1	C2	C3	C4	TOTAL	Ranking
Institutional regulations for technological innovation	-1,22067	-1,22067	-1,22067	-0,13971	-3,8017	1º
Economic policy	-1,22067	-1,22067	-1,22064	0,430728	-3,2313	3º
Investment policy	-1,22067	-1,22067	-0,76471	-0,43073	-3,6368	2º
Credit Policy and legislation	-1,22064	-0,76471	0,13971	0,76471	-1,0809	8º
Licensing	-1,22067	-0,76471	-0,43073	0,430728	-1,9854	6º
Policy and legislation for consumer protection	-1,22067	-1,22064	-0,76471	0,76471	-2,4413	4º
Tax policy	-1,22067	-1,22064	-0,13971	1,220642	-1,3604	7º
Political Risk	-1,22067	-1,22067	-0,43073	0,430728	-2,4413	5º

Phase 3: Determining Degree of Knowledge Evaluation

The results generated in this phase define the modeling strategy standards for prospecting of knowledge in innovation value chain, which will be elaborated in the next phase.

The strategy modeling results from the variation between the degrees of knowledge (Prospected/Desired - D and - Real - R) developed at this stage, in two steps: (i) determining DDKE – Degree of Prospected/Desired Knowledge Evaluation for performing the activities and actions considered by the AIs. 2) Determining DRKE – Degree of Real knowledge evaluation. The actual knowledge is the knowledge the individual has at the moment preceding the PDP.

Step 1: Determining DDKE: The neurofuzzy technology will be applied to obtain DDKE, which is a credible and feasible modeling tool, structured according to the analogy of Cury's model developed in 1999, with hierarchical architecture, which brings together the experts' degrees of evaluation (previous estimates), with the interaction of all the data in inference blocks that uses fuzzy rules and verbal expressions, resulting in knowledge evaluation by means of weighting, which produces the degree of knowledge evaluation (DKE) (Cury and Veiga, 2004; Cury,1999). The neurofuzzy technique was chosen due to the high subjectivity of the variables in the process and the relevance of the decision maker's opinion, which is an appropriate method for this application, as it allows the interaction of variables converged into a single evaluation parameter (Oliveira and Cury, 2004). Under this proposal, the model is systematized according to the steps: (i) definition of input variables, (ii) definition of the inference system, and (iii) definition of the output variables (Figure 2).

Architecture of the Neurofuzzy Network: In each network node, two or more elements are assembled in one single element, originating a new node. This new node is then added to other nodes, produced in parallel, which give rise to a new node. And so on, until the final node is attained. The neurofuzzy network architecture (NNA) is defined by the input variables in its first layer, always converging to their network nodes. Each node corresponds to a fuzzy rule base, designated as Inference Block (IB), in which the linguistic variables are computed by aggregation and composition in order to produce an inferred result, also in the linguistic variable form.

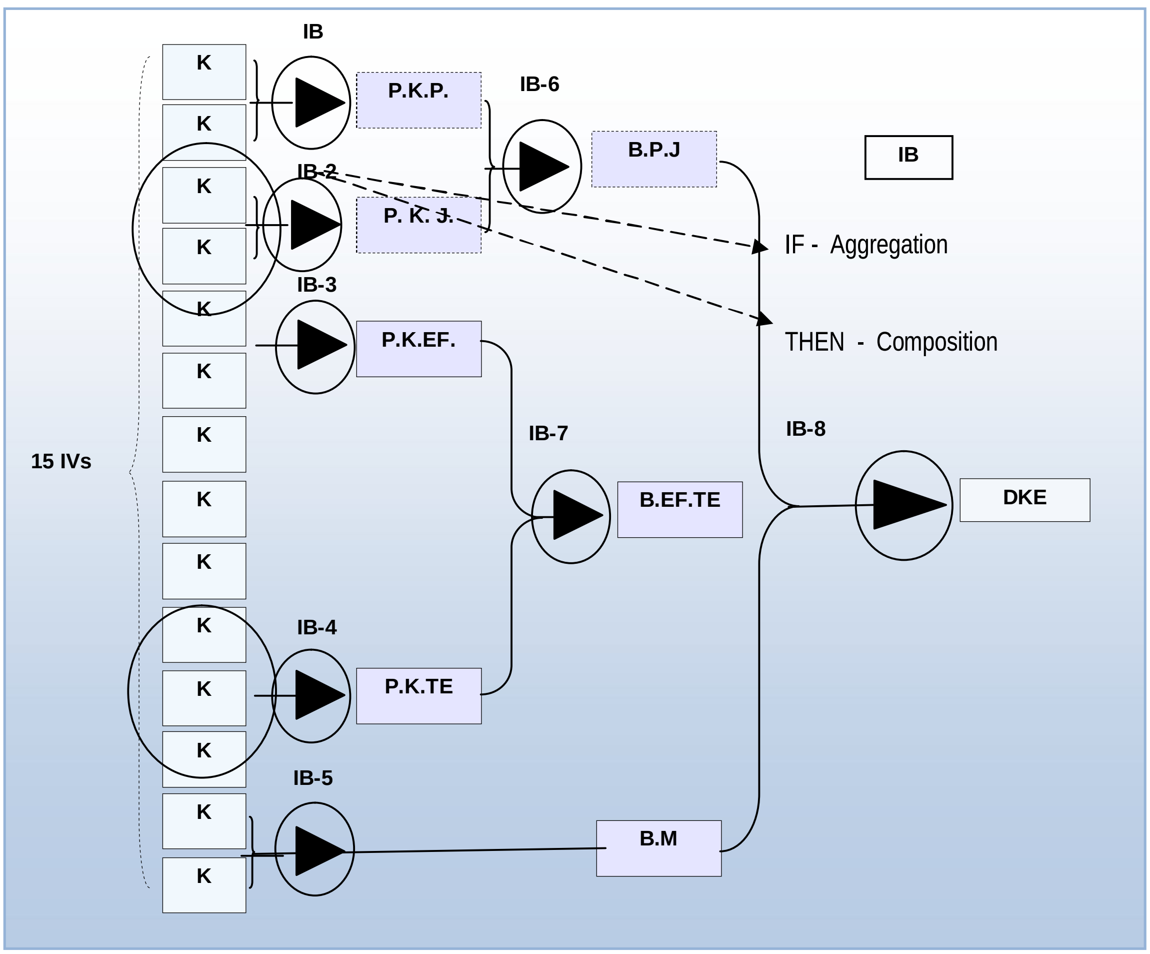

Figure 2: Neurofuzzy Model - DDKE

Thus, the rules are defined in the IB of NNA. In summary, the input variables (IV) pass through the fuzzification process and through the inference block (IB), producing an output variable (OV), called the intermediate variable (IVa), if it does not correspond to the last IB on the network. This IV, then joins another IV, forming a set of new IVs, hence configurating a sequence on the last network. In the last layer, also composed of IV, it produces the output variable (OV) of the final NNA. This OV then undergoes the defuzzification process so that the final result is obtained in the DDKE analysis. The NNA architecture should be applied according to the number of specialists. These steps are detailed below.

Sub-step 1: defining the input variables: The structure of the method helps to extract the experts' perceptions about the minimum knowledge prospected/required (DDKE) for the performance of activities and actions in AI (application object). The IVs that interfere in the process, as previously referenced, are identified and evaluated in the previous phase with the intervention of the experts. A representative sample of experts is recommended. These IVs, which are: knowledge transformed into linguistic variables, with their respective degrees of certainty or conviction (GDC), depending on the interaction between the experts, based on fuzzy[1] sets and on the IF-THEN rules.

This phase is called fuzzification, since it uses the fuzzy sets for such conversions. The GDCs are defined subjectively, based more on pragmatism than on statistics. The variables are qualitative and the linguistic terms are assigned to each IV: High, Medium and Low. Each IV must be characterized and should have defined numerical or linguistic values. And the lack of measures for the qualitative IVs can be accommodated by converting the observation fields into linguistic variables, by assigning, according to the experts' perception of evaluation degrees, a 1 to 10 scale, using an instrument (Form or Questionnaire). The IV undergoes the fuzzification process, according to the numerical scores that reflect the experts' feelings. Thus, the generic fuzzy sets should be defined for all qualitative IVs, which always have three levels of linguistic terms: a lower, middle and superior level.

The construction of these fuzzy sets is based on the experts' representative sample, who assign linguistic terms to all the scores of the 1 to 10 scale, within a generic context. In short, the input variable is used, whose linguistic terms are: High, Medium, Low, and the expert is asked to assign a score (0 to 10 scale) to the study object (weighted by importance). Next, the fuzzification process of the qualitative variable takes place. In summary, once the IVs and their linguistic terms are defined, they are input into the neurofuzzy inference system network, hierarchically created, using the IF-THEN rules, thus providing evidence to the degree of knowledge evaluation (DKE) through a final linguistic variable, which through a linguistic defuzzification process indicates the previous DDKE.

In summary, based on data collected in Phase 3 (identification and capture of the knowledge objects), to achieve this step, the top 15 knowledge classifications were selected to feed the input variables in this Phase and Step. For example (hypothetical), when the expert's opinion was solicited about which prospected/desired degree of technical knowledge the product development manager (technology-based company) should have, the answer was 7.0. Next, the fuzzification process (simulation) took place, assigning the linguistic terms: LOW, MEDIUM and HIGH levels of evaluation on a 1 to 10 scale. For score 7, considered LOW by 0% of the specialists, MEDIUM by 55% and HIGH by 45% (Table 3).

Table 3: Fuzzy Sets – IV Technical Knowledge Desired

Experts	Linguist terms	Degree of knowledge									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	LOW										
	MEDIUM										
	HIGH										
2	LOW										
	MEDIUM										
	HIGH										
3	LOW										
	MEDIUM										
	HIGH										
20											
	LOW	100	100	55	25	0	0	**0**	0	0	0
Degrees of certainty	MEDIUM	0	0	35	75	100	90	**55**	40	0	0
(DoC) **(%)**	HIGH	0	0	0	0	0	10	**45**	70	100	100

With the specialists' responses the degree of certainty of linguistic terms in each of the input variables was determined using the fuzzy sets. The generic fuzzy sets were defined for all the qualitative IVs, which always have three levels of linguistic terms: a lower, middle and higher level (Table 4).

Table 4: Generic fuzzy sets for IVs – linguist terms

Knowledge	Characteristics	Linguist terms		
K. Technical	Qualitative	LOW	MEDIUM	HIGH
k. Economical and Financial	Qualitative	LOW	MEDIUM	HIGH
K. Market	Qualitative	LOW	MEDIUM	HIGH
K. Policies	Qualitative	LOW	MEDIUM	HIGH

Sub-step 2: Treatment of Intermediate Variables and Linguistic Terms

Once the IVs are defined, they undergo the fuzzification process and the inference block, hence producing the output variables (OV), called the intermediate variable (IVa), which then joins other IVs, forming a new set of IVs, therefore constituting a sequence until the last layer of the network. In the last layer, the definitive output variable (OV) of the Neurofuzzy Network is produced. This OV then undergoes the defuzzification process to obtain the final result. The Fuzzy Inference corresponds to the fuzzy inference rules that consist of IF-THEN rules, which are responsible for the association of the input variables and generation of OVs in linguistic terms, with their respective pertinence functions. The rules constructed depend on the previous layer of IVs, and then generate the OVs. Based on the MIN-MAX operators, a linguistic vector of the IVs is obtained for the final OV of the method, whose linguistic terms were previously defined by the method. After converting all IVs into their corresponding linguistic variables, with their respective GDC, the "fuzzy" inference blocks (IB), composed of IF-THEN rules, are operated based on MIN-MAX operators, hence obtaining a linguistic value for each intermediate variable and for the output variable of the model, with the linguistic terms previously defined by the judges. With the input variables, the rule base is created. Each rule has an individual weighting factor, called the Certainty Factor (CF), ranging from 0 to 1, which indicates the degree of importance of each rule in the fuzzy rule base. And the fuzzy inference occurs from the rule base, generating the linguistic vector of the OV, obtained through the aggregation and composition steps. Table 5 shows the linguistic terms assigned to the intermediate variables.

Table. 5**:** Linguistic terms assigned to the Intermediate Variables

Intermediate Variables	Linguistic terms		
Benefit Policies / Judicial	LOW	MEDIUM	HIGH
Benefit. Market	LOW	MEDIUM	HIGH
Benefit. Economical and Financial / Technical	LOW	MEDIUM	HIGH
Performance Policies	LOW	MEDIUM	HIGH
Performance Judicial	LOW	MEDIUM	HIGH
Performance Market	LOW	MEDIUM	HIGH
Performance Economical and Financial	LOW	MEDIUM	HIGH
Performance Technical	LOW	MEDIUM	HIGH

As a demonstration, Table 6 shows some linguistic vectors of the IVs and OVs, for the specialist.

Table 6**:** Linguistic Vectors of IVs – Specialist

Parameter	Linguistic terms	Degrees of certainty (DoC)
Benefit Economical and Financial / Technical	LOW	2%
	MEDIUM	7%
	HIGH	88%
Benefit. Market / Policies	LOW	0%
	MEDIUM	5%
	HIGH	90%

Sub-step 3: Treatment of Output Variable – Level of Knowledge Evaluation – DKE

The output variable (OV) of the Neurofuzzy model proposed was called Degree of Knowledge Evaluation – DKE. To enable the comparisons, the final output variable of the method, in other words, the linguistic vector of DKE must undergo the defuzzification process to be transformed into a real number, between 0 and 1. In defuzzification, the fuzzy system, when receiving an input, converts it into a "fuzzy" input, which is then submitted to the inference system (fuzzy rules) that returns a fuzzy output to this system. However, a numerical value in the output is desirable in many cases. Defuzzification is not exactly the inverse process of fuzzification. Therefore, the fuzzy set, besides an X universe, is a set of orderly pairs represented by Equation 1.

$$A=\{(\mu_A(x),x)|x \in X\} \quad (1)$$

Where $\mu_A(x)$ is a function of pertinence (or degree of pertinence) of x in A and is defined as the mapping of X in the closed interval [0,1], in agreement with Equation 2 (Pedrycz and Gomide, 1998).

$$\mu_A(x):X\rightarrow [0,1] \quad (2)$$

The method proposed suggests the Center of the Maximum (CM) technique in the treatment of OV, which is one of the most widely used defuzzification techniques to transform a linguistic result into a numeric value again, according to Von Altrock (1997) *apud* Cury and Veiga (2004). Most of the "fuzzy" logic systems use this step because the desired result often needs to be expressed in numerical form, rather than in the linguistic form. The DDKE value, which always belongs to the interval [0; 1], represents the experts' measure of preference intensity regarding the desired knowledge. For a DDKE equal to 1, the preference for knowledge is maximum, within the standards established in this method. On the other hand, for a DKE equal to 0, it means that this preference has no value in the expert's preference. In summary, the third and last stage of the "fuzzy" logic system, called defuzzification, translates the linguistic result of the fuzzy inference process into a numeric value (Von Altrock,1996) for comparison purposes. The Degrees of certainty (DoC) that determine the linguistic vectors resulting from the processes of aggregation and composition are defined by Equation 3.

$$GdC;:max[FC_1 \, . \, min\{GdC_{A11},GdC_{A12},...,GdC_{1n}\},...,FCn \, . \, min\{GdC_{An1},GdC_{An2},...,GdC_{Amn}\}| \quad (3)$$

In this case, after the fuzzy inference, a defuzzification process is required, that is, transform the linguistic values into numerical values from their pertinence functions (Von Altrock, 1997 (*apud* Oliveira and Cury, 2004). Usually, the Maximum Center method is used to determine an exact value for the Exit Variable linguistic vector. From this method, the certainty degree of the linguistic degrees is defined as "weights", associated to each of these values. The exact resolved value (RV) is determined by considering the weights in relation to the typical values (maximum values of the pertinence functions), in agreement with the definition of the Equation (Von Altrock, 1997).

$$RV=\frac{\sum_{i=1}^{n} DoC_i \, . \, X_i}{\sum_{i=1}^{n} DoC_i \, . \, X_i} \quad (4)$$

Where DoC represent the degrees of certainty of the linguistic terms of the final output variable and X indicates the typical values for the linguistic terms that correspond to the maximums of the fuzzy sets, which define the final output variable. As a demonstration (hypothetical), attributing hypothetical degrees (average), the calculation of DDKEj is expressed with the GdCi of following linguistic vector of the output variable DDKE, also hypothetical: LOW = 0.28, MEDIUM = 0.47, HIGH = 0.14. The score of the numeric DDKE in a 0 to 1 scale corresponds to 0.6428, the result of the arithmetic mean of the scores resulting from the defuzzification of each of the twenty simulated judges. This score corresponds to an average value of DDKE. The following are the procedures for determining the previous DRKE of the members involved in PDP.

Step 2: Determining the participants previous DRKE: The methodological procedures were applied to five (hypothetical sample) members who participated in the PDP. The average of the results produced was then calculated. To know the level of knowledge of that team, a test with sixty closed-ended questions was applied, according to the four knowledge categories necessary for managing the product development projects.

Based on the evaluation of the results, an adjustment in a 1 to 5 scale was performed, where 1 represents the minimum importance score or the knowledge domain and 5 represents the maximum score. Then, the mean and standard deviation of all participants were calculated. The results are shown in Figure 3.

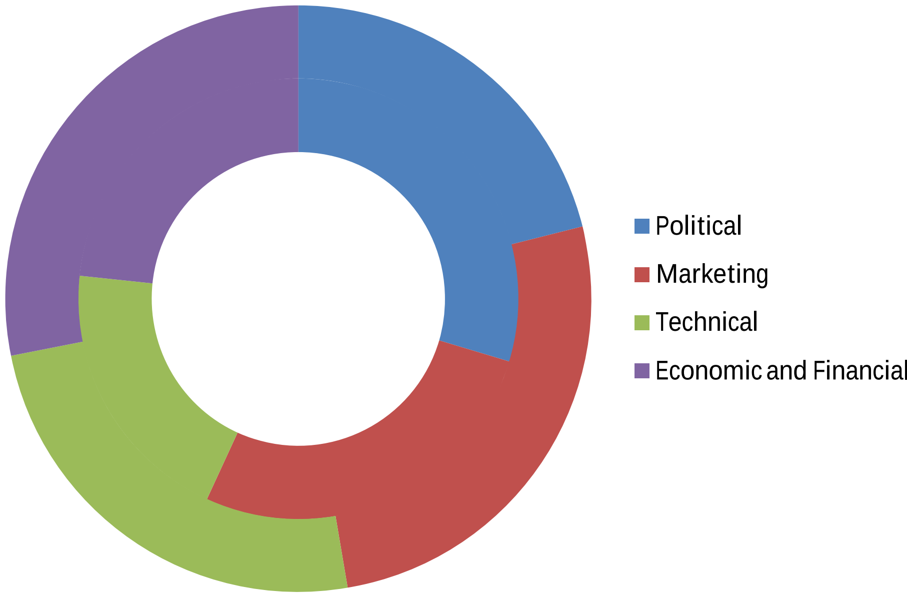

Figure 3: Mean and Standard Deviation of the knowledge- Political - P, Economic and Financial - E, Marketing - M, Technical –T

Combining the dimensions it can be stated that on average there is no predominance of one or another, with slight relevance to the market knowledge (M=3.64). And when analyzed internally, it was observed again that in the economic and financial group, there is a stronger preference for some knowledge objects (dp=1.13). In this perspective, regarding the values resulting from this preliminary analysis, at this stage the average size, the input variables for neurofuzzy modeling are considered, converging to DRKE. The result of this interaction for the actual knowledge produces the DRKE of the PDP team members on a scale of 1 to 10, which are the IV scores of the neurofuzzy system. The same procedures (architecture) were used in the DDKE calculation to achieve the DRKE. For example (hypothetical), using the assigned degrees (average), we have the calculation of DAKEj with the GdCi of the following linguistic vector of the output variable DRKE, also an example: (LOW = 0.28, MEDIUM = 0.40, HIGH = 0.11). To find the numerical DRKE, there is the defuzzified score of the linguistic variable DRKE on a scale of 0 to 1.

Thus, the DRKE shown corresponds to 0.4246. The three degrees of knowledge evaluation are compared (triangulation, - the previous degree of knowledge desired and degree of real knowledge versus post level of knowledge evaluation). This phase ends with the analysis and evaluation of the discrepancies between the degrees of knowledge and the proposed adjustments to model the strategies on the PDP value chain. With the score results in this Phase, based on the specialized literature and the judges' intervention, the strategies on the knowledge networks (value chain) are defined. The procedures are detailed in the next Phase.

Phase 4: Modeling of Strategies for prospecting of Knowledge in innovation value chain

In light of the results produced in the previous phase and based on the state of the art, a model is proposed to identify the strategies for prospecting of knowledge in innovation value chain (in the PDP) according to the following phases: Phase (i) Analysis and evaluation of DDKE and GRKE, according to the intensity of their individual variations. Phase (ii) Survey of Strategies. The first phase will be through the experts' intervention and experience, considering the not very high number of participants. As a preparatory stage towards the definition of PDP strategies, it is necessary to identify the results produced by the variation between the desired and real personal knowledge, previously defined in the PDP. That is, before starting the product development process.

Next, with the results, the experts use a judgment matrix to attribute weights according to the intensity of their preferences to prioritize strategies for the variation of the desired and real personal knowledge (previously) in the PDP. With the results produced by DRKE (individual) and DDKE, both before the PDP, a judgment matrix (nature of the strategies versus knowledge) is produced, which has the experts' interference in the process, assigning weights to strategies based on the intensity of the degrees of knowledge. In other words, the experts assign weights to strategies according to the gap between the desired and real degree of knowledge. The strategies are always oriented toward DDKE. It should be noted that these strategies are confirmed on a permanent basis after consulting the experts, who assign weights according to the varying degree of knowledge evaluation. The experts' judgment framework shows the strategies performed to secure the actors' knowledge and reach the intended objectives DDKE: *(i) learning strategies; (ii) quality differentiation strategies; (iii) image differentiation; (iv) strategies for mass customization* and; (v) support strategies; *(vi) design differentiation strategies*; *(vii) package strategies*, in that order, respectively.

4. Conclusions and Implications

This work intends to contribute to the planning policy guidelines in the field of innovation value chain in the product development process. Thus, it develops a multi-model proposal to determine Strategies in Prospecting of knowledge. The central element of the model is the prospecting of knowledge by the members of the multidisciplinary teams according to the PDP. This was possible by assessing the degree of knowledge evaluation of the actors in the multidisciplinary teams before and after the PDP. Therefore, the prospecting of knowledge is developed in light of the strategies. Considering the various dimensions, the results show that there is no considerable predominance of one or another degree of knowledge, but it is certain that this knowledge is on the agenda and should be marked out as a timely priority, in the context of systemic efforts in order to define and redefine new planning strategies over time. It is plausible that the prospecting of knowledge takes place over a continuous process and converges to the desired profile, which is constantly changing due to the acquisition of new knowledge. In this way, the policy of product development will be anchored in an instrumented planning in view of the actors of the multidisciplinary teams.

Taking into account the methodological procedures, in this field the technique imposed a sufficiently robust and logical/scientific planning standard. The sophistication of the methodological procedures favored different dimensions required to understand and interpret the rationale behind the PDP in the value chain. The model is a valuable conceptual tool. It is also clear that the list of priorities of the actors' knowledge in the multidisciplinary teams is dynamic, dependent on the existing knowledge and skills essential and desirable in PDP, which emerge during practice, always putting new concepts, new content and demanding new behaviors and technical implementations, which fundamentally requires the ongoing and recurrent reconfiguration that joins the list of new strategies in the knowledge network.

Finally, it is important to reinforce that this methodological support does not intend to be complete, but rather as a generator of knowledge elements that are strategic for the development of products. Clearly, it does not intend to be a "straitjacket" methodology, but one that can make a contribution, even through freer paths, which makes the decision spectrum more intelligent, providing essential elements for the development of new products. Moreover, this study was applied to technology based companies in Brazil, and this may represent a limiting factor to this research. It should be considered that this instrument does use not always lead to practical results, since the situations require singularities, differentiating them from similar and apparently comparable situations. The social, cultural, economic, political, and especially technological situations are different. Moreover, these tools cannot be used to predict the future; at most the lessons can help find elements for future scenarios.

References

Abrahamson, E. 1991. Managerial fad and fashion: the diffusion and rejection of innovations. *Academy of Management Review*. 16, 586-612.

Beugelsdijck S., Cornet M., 2001. How far do they reach? The localisation of industrial and academic spillovers in the Netherlands', Centre discussion paper 47.

Bottazzi, L., Peri, G., 2002. Innovation and spillovers in regions: evidence from European patent data. *European Economic Review* 47, 687-710.

Buchanan, M., 2002. Nexus: small worlds and the groundbreaking theory of networks, Norton.

Camagni, R, 1991. Local 'milieu', uncertainty and innovation networks: towards a new dynamic theory of economic space, ch 7, 121-142 in Camagni, R (ed) Innovation Networks: Spatial Perspectives, Belhaven Press, London.

Cury, M. V. Q. 1999. Modelo Heurístico Neurofuzzy para Avaliação Humanística de Projetos de Transporte Urbano. Tese submitted for the degree of. Doctoral of Science in Production Engineering of University Federal of Rio de Janeiro, COPPE/UFRJ.

Cury, M. V. Q.; Veiga, F. J. P., 2004. Método para avaliação do desempenho de rodovias concessionadas sob a ótica do usuário.

Damanpour, F., 1996. Organizational complexity and innovation: Developing and testing multiple contingency models. *Management Science* 42 (5), 693-713.

Griliches, Z., 1990. Patent Statistics as Economic Indicators: A Survey, *Journal of Economic Literature* 28: 1661 1707.

Martin, C. R., Horne, D. A., Schultz, A. M. 1999. The business-to-business customer in the service innovation process. *European Journal of Innovation Management,* Vol 2. Nº 2, 55-62.

Oliveira, R. L. M.. Cury, M.V.Q., 2004. Modelo neuro-fuzzy para escolha modal no transporte de cargas. Dissertação de Mestrado apresentada ao Curso de Mestrado em Engenharia de Transportes do Instituto Militar de Engenharia.

Pedrycz, W.and Gomide, F., 1998. An introduction to fuzzy sets. Cambridge, MA: MIT Press, 480.

Powell, W.W., Grodal. S., 2005. Networks of Innovators. In J. Fegerberg, D.C. Mowery and R.R. Nelson (eds.), The Oxford Handbook of Innovation. Oxford: Oxford University Press. 56-85.

Power, D. 2005 Supply chain management integration and implementation: a literature review, *Supply Chain Management: An International Journal*, 10, 252-63

Teece, D. J., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. *Strategic Management Journal*, 18 (7), 509-533.

Teece, D.J., 1986. Profiting from technological innovation. *Research Policy* 15 (6), 285–305.

Thiel, E.E., 2002. Proposta de modelo de implantação de um projeto de gestão do conhecimento com base em processos organizacionais. Dissertação de Mestrado apresentada ao Departamento de Engenharia de Produção da Universidade Federal de Santa Catarina.

Thurstone, L. L ., 1927. A law of comparative judgment. Psychological *Review*. England.

Tidd, J. ; Bessant, J. ; Pavitt, K., 1997. Managing Innovation Integrating Technological, Market and Organizatioinal Change, John Wiley & Sons, New York.

Von Altrock, C. 1997. *Fuzzy Logic and Neurofuzzy* Applications in Business and Finance. Prentice Hall, USA.

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