Multi-Model Standard Reference for Strategies in High Complexity Spectrum Using Hybrid Intelligent Architecture

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Abstract

The objective of this paper is to contribute to a planning policy in the knowledge innovation/network value chain in the perspective of the product/technology development process – PDP/TDP. Therefore, a multi-model reference proposal was created based on the definition of high complexity spectrum strategies, which considers a sequence of systematic procedures in the following phases: 1) Mathematical modeling, structured into (i) theoretical assumptions to design the model, and (ii) theoretical elements to design of the model, and 2) verification of the mathematical model, systematized in the following steps: (i) determine the information needs in two sub-steps: (a) identify critical success factors (CSFs) and (b) identify information areas, (ii) determine the actors' knowledge in the innovation value chain, (iii) determine the degree of knowledge evaluation, and (iv) determine the strategies in knowledge networks in the innovation/knowledge value chain networks in the products/technologies development process. The study shows thes application of this process in technology based companies in Brazil and thes research work was done with the participation of experts with technical and scientific knowledge about the research object. Several support tools weree 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, Artificial Neural Networks (ANN) and Neurofuzzy Technology. The mains results obtained demonstrated that.

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 believed that companies that can offer their products to customers more efficiently and faster will probably be in a better position to create a sustainable competitive advantage (Prahalad and Hamel, 1990; Amit and Schoemaker, 1993; Nonaka and Takeuchi, 1995; Calanton et. al., 1995) due to knowledge and innovation (Teece et. al., 1997; Nelson and Winter, 1982; Nonaka and Takeuchi, 1995; Leonard-Barton, 1995; Grant, 1996a; 1996b; Johannessen, Olaisen, Olsen, 1999). In this dichotomy, technical efficiency is a parameter of the developing capacity of innovative products, which translates into one of the most remarkable logical arguments to potentialize and encourage competitive advantage (Wheelwright and Clark, 1992; Brown and Eisenhardt, 1995). One of the main challenges is to develop products in high complexity environments. Solutions to these challenges have been offered by the companies' equally innovative technical capabilities, greater efficiency, productivity and high quality (Wheelwright and Clark, 1992).

Developing products is not a recent phenomenon, but reconstruction presents successful and unsuccessful experiences.

Any attempt to encourage reconstruction and interpretation refers to, first of all, a proper analysis of the difficulties and peculiarities of the product development chain, the “opposite semantics due to the systems’ diversity of features – structures, methods and organization”. The reconstruction then uses a “mantle” that takes advantage of the experience accumulated by the actors in the product development process of the value chain, considering the learning process for the construction of knowledge. In any case, product development is a complex chain of events and decisions, which can break at any of the weakest link: some projects lost due to unrealistic predictions or the absence of its real role in the agenda, or other motivations that somehow followed ideas that had many missteps or a detail error.

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. This requires an integrated and shared decision structure that involves key business processes, concerning efficient coordination of functional-temporal company-client (Cheng, Yeh, and Tu, 2008; Power, 2005; Blos, et. al., 2009; Fawcett, et. al., 2009; Godsell, Birtwistle, and Hoek, 2010; Halldorsson et. al, 2007; Kim, 2006; Svenson, 2007).

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

This process should result in people with adequate knowledge to perform tasks correctly at the right place and opportune moment (Mangan and Christopher, 2005). The knowledge may represent a strategic tool, increasing the institutional capacity of the Entrepreneurs in their assignments of formulation, evaluation and execution of such projects (Fletcher, Yiannis, and Polychronakis, 2007; Hanisch et. al., 2009; _Kannabiran, 2009; Kayakutlu and Buyukozkan, 2010). The knowledge would work as a facilitator instrument of improvement, contributing for the quality of services and the enhancement of the agility to decide.

Monitoring the performance of value chain from a knowledge perspective requires that the appropriate monitoring procedures are in place and operational (Fletcher, Yiannis, and Polychronakis, 2007; Godsell, Birtwistle, and Hoek, 2010; Svensson, 2007). Generally, a keen eye must be kept on the knowledge household of value chain. Especially important is watching the external environment for new events that may have impacts on the way value chain deals with knowledge shown as “incoming” arrows that will influence on the performance of value chain. In order to improve the performance of the entire value chain, it is necessary to cross the boundaries of individual companies and consolidate the entire chain, in other words, a cohesive and integrated system to increase the chain’s knowledge flow.

Generally, the VCM models are usually developed by conventional modeling techniques, including mathematical programming, simulations, heuristics and statistical and probabilistic tools. However, none of these planning and managing models listed by the literature investigated takes into consideration the priority of cognitive elements in the value chain management. The purpose of this paper is to contribute to a planning policy in the innovation/networks value chain of knowledge in view of the product development/technology process – PDP/PDT. Therefore, a multi-model reference proposal was created based on the definition of high complexity spectrum strategies, which considers a sequence of systematic procedures in the following phases: 1) Mathematical modeling, structured into (i) Theoretical assumptions to design the model, and (ii) Theoretical elements to design of the model, and 2) Verification of the mathematical model, systematized in the following steps: (i) determine the information needs in two sub-steps: (a) identify critical success factors (CSFs) and (b) identify information areas, (ii) determine knowledge of the actors in the innovation value chain, (iii) determine the degree of knowledge evaluation, and (iv) determine the strategies in knowledge networks in the innovation/knowledge value chain networks in the products/technologies development process. This work is systematized in the following sections: 2 – Modeling; 3 – Method to verify the model; and lastly, the Final Remarks.

2. Modeling

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 CSFs, knowledge and strategies of the 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 the 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 the PDP/TDP of technology based companies. Thus, the following assumptions are presented:

(i) The PDP/TDP 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/TDP 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 product development process of technology PDP/development 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 product development of projects/technologies; (v) product 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 the product development process and helps identify the value chain innovation potential (knowledge networks).

(iv) The environment's configuration characteristics (individual preferences directly influence individual decisions for products 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 development of innovative products.

(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) product 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 product 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 products given simultaneous engineering.

(IV) 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/TDP.

(vii) The construction of knowledge in the PDP/TDP innovation value chain is based on the **CSFs** of the desired reference by the multidisciplinary team members, and therefore influences the definition and redefinition of strategies in the PDP/PDT innovation value chain/knowledge networks.

(viii) The cultural characteristics of PDP/TDP multidisciplinary teams directly influence strategies in the PDP/TDP innovation value chain. The interrelationship modifies the decisions that affect the performance of the PDP/TDP 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/TDP.

(xi) Given that a system represents several objectives to meet the needs related to individuals/members of the PDP/TDP 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/TDP multidisciplinary teams, and between them and other actors.

The inclusion of strategic variables then enables analyzing the performance of the PDP/TDP 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/TDP 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/TDP knowledge/value chain networks should include flexible strategies according to the individual characteristics of the PDP/TDP 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/TDP 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 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 the product development process starts, and ends when the product development process concludes, which presupposes knowledge construction. 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 product development process (PDP/TDP).

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 product development process. Knowledge can be classified into two groups: Theoretical Foundations + Information Concepts **(TF + IC)**. The "+" represents the construction time increase of knowledge during the PDP/TDP.

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 product development process, generated from the CSFs. 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 product development process. 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 products.

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/TDP. 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 desired knowledge (DK), i.e., f (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 desired knowledge (DK), i.e., f (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 construction 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/PDT. 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 (in knowledge networks). The interrelationship of factors affects the decisions that affect the performance of the innovation value chain in the product development process.

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 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 acquired (desired) given the strategies used during PDP/TDP. 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= Ω { Individuals **(I),** Critical Success Factors (**W**), knowledge (**K**), Strategies (**S**)**}**

Modeling Constraints

Recursion: The conditions of the previous state "State (N)" influence the following state "State (N+1)"; and **Linearity:** the conditions of the following State "State (N +1)" are not influenced by the previous state "State (N)".

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.

Temporal Continuity: represents the time limit before and after the product development process 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 process/PDP//individual, and the dependency relationship of individual knowledge in relation to 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=BTIC

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

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 **($TBCI_I$**/$TBCI_D$**)**, 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):

$$N' = ß_1 + \Omega\ f\{((ß_2 \Delta DKE), f(ß_3 W_n)) + u_i\} \quad (1.6)$$

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

$$N' = ß_1 + \Omega\ f\{((ß_2 \Delta X_1), f(ß_3 X_2)) + u_i\} \quad (1.7)$$

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*. The overall fit of the model was measured by the determination coefficient $r^{2.}$ The "F" test was also used to verify the structural stability of the model. This test also decides whether or not to add other variables to the model, which allows an increase to the model. With the model development, the next step is to verify the model. This was possible by a set of integrated and connected methods.

3. Method to Verify the Model

To demonstrate the feasibility and plausibility of the model, a hypothetical implementation was carried out in the technology development process in a technology based company in Brazil. The research area was composed of experts selected by technical-scientific criterion, these specialists are knowledgeable regarding the study object: (i) specialists in designing and implementing projects for product development, (ii) specialists in innovation management, and (iii) experts in organizational management. Next, The detail of the phases and steps.

Phase 1: Decision Making and Problem Solving: As a preparatory phase of this reference model, the structure of the research problem was elaborated using the Soft Systems Methodology (SSM). The "Brainstorming" technique and the stated preference will be used as data collection support. The problem of 'how should the structure of a reference model based on the definition of high complexity spectrum strategies be?' is addressed. Next, the solution of this problem is presented.

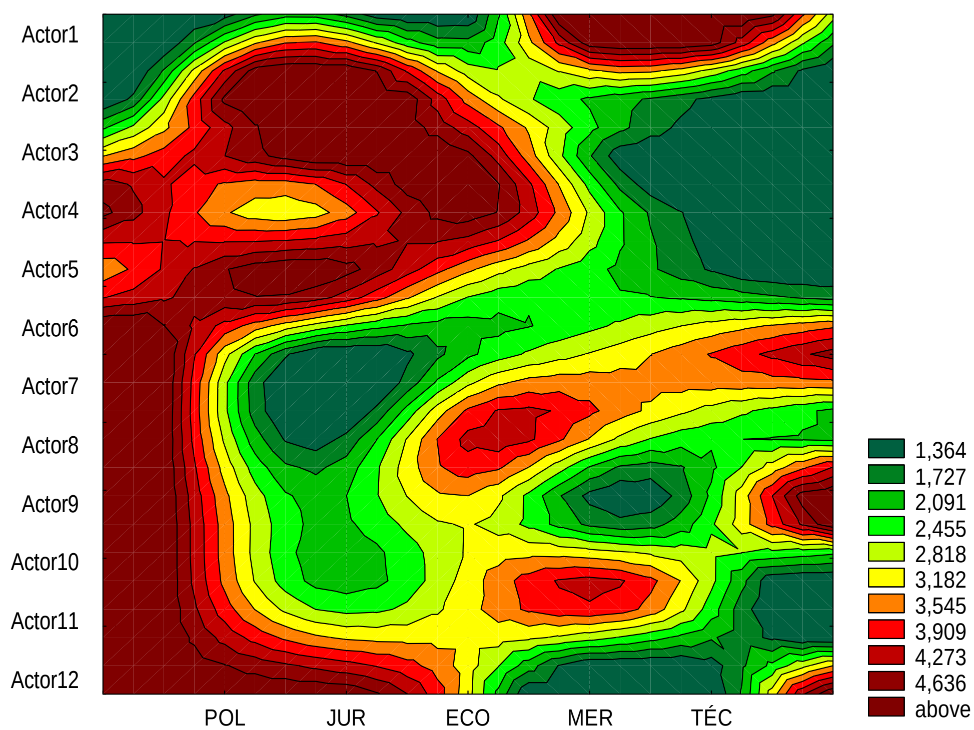
Phase 2: Modeling the Information Needs - CSFs - $W_{n:}$ This phase is subdivided into: modeling the CSFs and modeling the information areas.

Step 1: Modeling the CSFs (W): This step is focused on determining the CSF, and is itself structured in two stages: (A) identification of CSF and (B) evaluation of CSF. (A) *Identification:* The identification of CSF is based on the combination of various methods (Liedecker and Bruno,1984): (a) environmental analysis (external variable: political, economical, legislation, technology, among others.); (b) analysis of the industry structure (users' needs, the evolution of the demand, users' satisfaction level, their preferences and needs; technological innovations); (c) meeting with specialists and decision makers; and (d) the study of literature. The experts' intervention is crucial to evaluate the CSFs. Once the CSFs are identified, the next step is to group them for a better understanding, using the "cluster" technique, according to the tree structure principle, which distributes the CSFs in different processes or areas involved, but always observing the relevant relationship.

Table 1: CSFs (W) in PDP

CSFs	(□i $=\sum_{j=1}^{4} Zij$	Ranking
Policies	-1,23029	**1º**
Market	-0,36956	**2º**
Economical and Financial	1,81628	**3º**
Technical	11,7347	**4º**

After organizing the CSFs (W) groups, for each "cluster" (elements and subelements), the next step is to apply Thurstone's psychometric scaling method (1927) to evaluate the grouped CSFs, in other words, prioritize the "clusters" according to their classification: first, the Political / Judicial Factor; second, the Technical Factor; third, the Economical and Financial Factor; and fourth, the Market Factor.



Step 2: Modeling the Information Areas - IAs:

After determining the CSF, the determination of the areas of information ensues. Thus, after their identification, the IAs 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. This model starts from the mental behavior to explain the preference of a judgment (individual) concerning a set of stimuli $\{O_1, O_2, \ldots, O_n\}$. Thus, the evaluation of the IAs 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. It is highlighted through the results to be achieved in Step 3 that reflect the probabilities of the intensity of the specialists' preferences regarding the stimuli, the IAs in this work. As a result, a hierarchical structure of IAs is obtained.. The goals of the areas of information define specifically what must be achieved by these areas to meet one or more objectives The result has allowed defining four groups that represent the areas of information: *first*, the Governmental Area on Public Policies; *second*, the Market Area; *third*, the Economical and Financial Area*; fourth*, Technical Informationfrom the projects of the product development (business), contributing for the enhancement of the project performance as to quality, productivity and profitability.

Step 3: Performance of AIs in Relation to CSFs (W)**:** 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 ™ and (c) Electre III ™. The result has allowed defining four groups that represent the areas of information: *first*, the Governmental Area on Public Policies; *second*, the Market Area; *third*, the Economical and Financial Area*; fourth*, Technical Information. The critical knowledge for PDP is determined in the sequence.

Table 2: Ranking IAs

Information Área	Ranking		
	Promethee II	Compromise Programming	Electre III
Policies	**1ª**	**1ª**	**1ª**
Market	2ª	2ª	3ª
Economical and Financial	3ª	3ª	2ª
Technical	4ª	4ª	2ª

Phase 3: Modeling Knowledge - IK is ƒ (W_n)

Combining the dimensions proposed in the knowledge construction evaluation model, here denominated as: theoretical bases and concepts and context information structured in three steps as follows: **Step 1:** concept definition; **Step 2:** identification and capture, and **Step 3:** evaluation. The three dimensions are identified from the literature reviewed and confirmed by the experts. The first one is systematized.

Knowledge (K)

Step 1: Defining the Knowledge Concept (Nonaka and Takeuchi, 1995; Probst, Steffen, Romhardt, 2002; Seufert, Von Krogh, Bach; 1999): The main concepts and elements are summarized in this work. The sources are selected according to their relevance. The definition that permeates this application follows the proposal by Moresi (2001): data (processing), information (elaboration), knowledge (synthesis), intelligence, respectively. Data - discrete and objective set pertaining to the facts of a particular event or object. Therefore, a company's quantifiable and objective information and knowledge is stored in databases or documents. Information: message containing a transmitter and a receiver, whose meaning involves a new interpretation of something, based on a data set. The term knowledge is therefore defined as something that cannot be fully structured, cannot be fully captured. Knowledge follows the logic of Davenport and Prusak (1998), which is the most valuable information because someone gave it a context, a meaning, interpretation, someone thought about knowledge, adding his own knowledge insight, considering its broader implications. Davenport (2001), Moresi (2001); Bukowitz and Williams (2002); Probst, Steffen, Romhardt (2002) stress that knowledge is information produced, refined, evaluated on its reliability, its relevance and its importance. And it is through the synthesis of information that information is converted into knowledge. Next, this synthesis, information is assembled in blocks so that it can later be used by experts who filter it and standardize it to apply it to a specific situation.

Once this stream of defining "Knowledge" elements is exposed, the "Context Information - (CI) and the "Theoretical Bases and Concepts - (TBC) are adopted as a definition of knowledge in this application. Context information means the information analyzed and evaluated from the information areas in Phase 2, where such information was identified and captured (internal and external environment), from the specialized literature and through interviews (semi-structured forms) by the experts as needed in order to supply the development of activities and actions coordinated for the projects. Such information is basic to the efficiency and success of such projects. Such information is basic for the efficiency and success of the projects. The Theoretical Foundations and Concepts are understood as the conceptual skills. The conceptual skills represent the skills that involve the outlook of the organization or organizational unit as a whole, the ease of working with ideas and concepts, theories and abstractions. Next, we address how this knowledge will be identified and captured.

Step 2: Identifying and Capturing Knowledge: Identifying knowledge is the first step in the Knowledge Management process. Two fronts should be analyzed: context information and theoretical bases and concepts. The context information will be identified, captured and mapped in the making of Phase 1, through semi-structured interviews and forms applied and confirmed by the experts with knowledge about the object of study/implementation in the information areas (study/application object). Thus, once this stage is identified and captured, they will be elaborated, reviewed and evaluated to become understandable to the decision makers (information users) in the project assembly and management, application object, following the analogy and hierarchy of data, information and knowledge. Then, this information will be reviewed, organized and validated by the experts involved directly or indirectly with the application object (in this case, the process of product development – technology-based company). The procedure to identify the information derives from determining the relevant theories and concepts that are necessary to achieve the operation and management of such projects. Next, the capture of this previously identified knowledge (Phase 2).

"After analyzing and validating the information, comes the knowledge stage, i.e., the information understood. It is through knowledge that those who advise on decisions seek a more effective understanding of the problem situation" (Moresi, 2001). And this analyzed and evaluated information produces knowledge, which is the information elaborated, refined, abd evaluated regarding its reliability, its relevance and its importance. Knowledge is obtained by the interpretation and integration of various data and information to start building a framework of the situation (Moresi, 2001; Bukowitz and Williams, 2002; Probst, Steffen, Romhardt; 2002), and suggests the following methods as information analysis tools: SWOT Analysis, Synergies, "Benchmarking", Management Profiles, Technological Monitoring, Morphological Analysis, D'Aveni's Competitive Dynamic Analysis, Porter's Value Chain, and Scenario Techniques. The SWOT analysis was used in this work. Knowledge acquisition involves the extraction, interpretation and representation of knowledge in a given domain and is considered to be the most difficult and precarious stage. The capture process is the acquisition of knowledge and experience required to create and maintain the selected and mapped essential skills and knowledge areas.

Acquiring the knowledge (from specialists) implies, according to Buchanan (2002) and Kululanga and Mccaffer (2001) 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 on 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.

First, the information is collected. Next, combination and internalization through knowledge is set up, from explicit to explicit, because the information is already mapped and formalized so that it is better understood and synthesized to be presented so that, when possible, everyone has access to easier and faster understanding (information should be useful in decision making, thus it must be understood). The simple activity of comparing and contrasting information is a form of analysis. Here are some procedures to capture knowledge: (Thiel, 2002): Interview, Mapping Information, Mapping Knowledge and Communication. To convert information to the knowledge stage (transformation), the following procedure is adopted: 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. Others criteria was adopted: (i) determining the relevance and value of knowledge or information; (ii) determining the degree of reliability of that knowledge; (iii) identifying and consolidating useful knowledge and disposing redundant knowledge; (iv) hiring; (v) reducing uncertainty of unproven knowledge; (IV) identifying and proposing solutions to problems related to conflicting knowledge, and finally, (vii) setting up multiple views for non-selected cases of conflicting 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 PDP/TDP are identified. In other words, which knowledge and theory are required to be known in order to ensure the success of projects on DPP/TDP 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. Next, the knowledge objects are grouped for a better understanding. They are grouped in "clusters", according to the tree structure principle, which distributes the knowledge objects into different areas or processes, but always observing the relevance relationships, and supplemented by the pairing or "cluster" methods, in order to gather the sample data into groups (knowledge objects), classifying them in such a way that there is homogeneity within the group and heterogeneity between groups. After being identified and acquired, the knowledge is evaluated, with the aid of the Method of Categorical Judgments of Thurstone (1927) and artificial neural network (ANN). The results were produced according to the experts' judgment in relation to the stimuli; the knowledge elements, classifying them by importance, using a form. The knowledge objects are prioritized as follows (Figures 2 and 3).

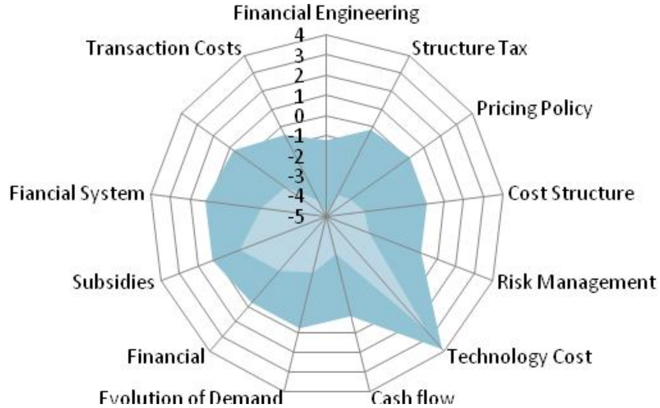


Figure 2: Theoretical foundations and concepts – Economic/Financial

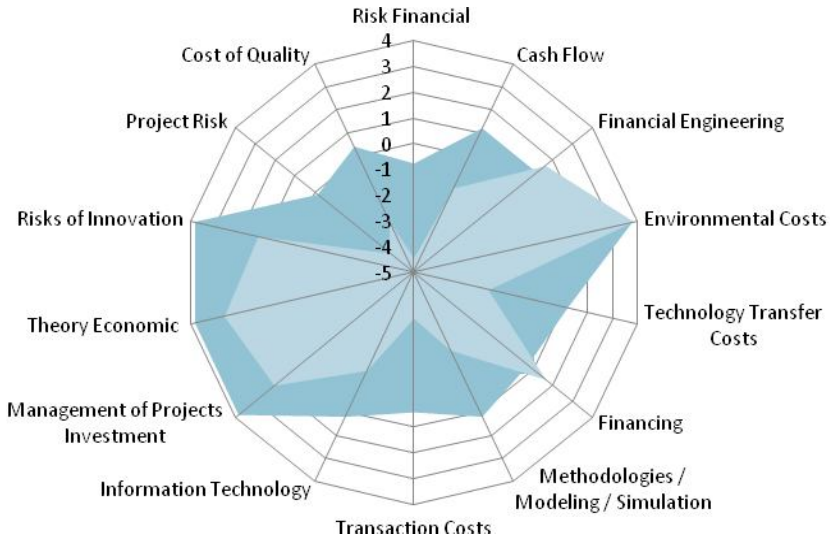


Figure 3: Context Information – Economic/Financial

After this procedure, a comparative analysis of changes in the actors' preferences (experts) was performed for the knowledge objects.

Comparative Analysis of the Actors' Preferences Changes

After being identified and acquired, the knowledge is evaluated, with the aid of the Method of Categorical Judgments of Thurstone (1927) and artificial neural network (ANN).

Evaluation for the method Categorical Judgments' Laws (1)

Stages The achievement method of the research results with the specialists of VCM, who revealed their preferences for pairs of stimulation (in the case, the objects of knowledge, and these submitted the ordinal categories C1 = 5º place, C2 = 3º place and C3 = 4º place). The evaluation of objects of knowledge (LJC) happened in three stages: In the stage (1), one determined the frequencies for pairs of stimulations, where Oi is equivalent to objects of knowledge and Oj the specialists. The data had been extracted from the preferences of the specialists in relation to objects of knowledge, attributing weights to the cognitive elements. After that (stage 2), the preferences of the specialists are determined in relation to the stimulations (knowledge). The results were 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 preferences intensity of the specialists in relation to the stimulations (theoretical bases and concepts). The result of the preferences, then, is presented in an upward order of importance. In order to demonstrate the application of the methodological proposal, the results of the objects of knowledge on the "Market Area " were dealt.

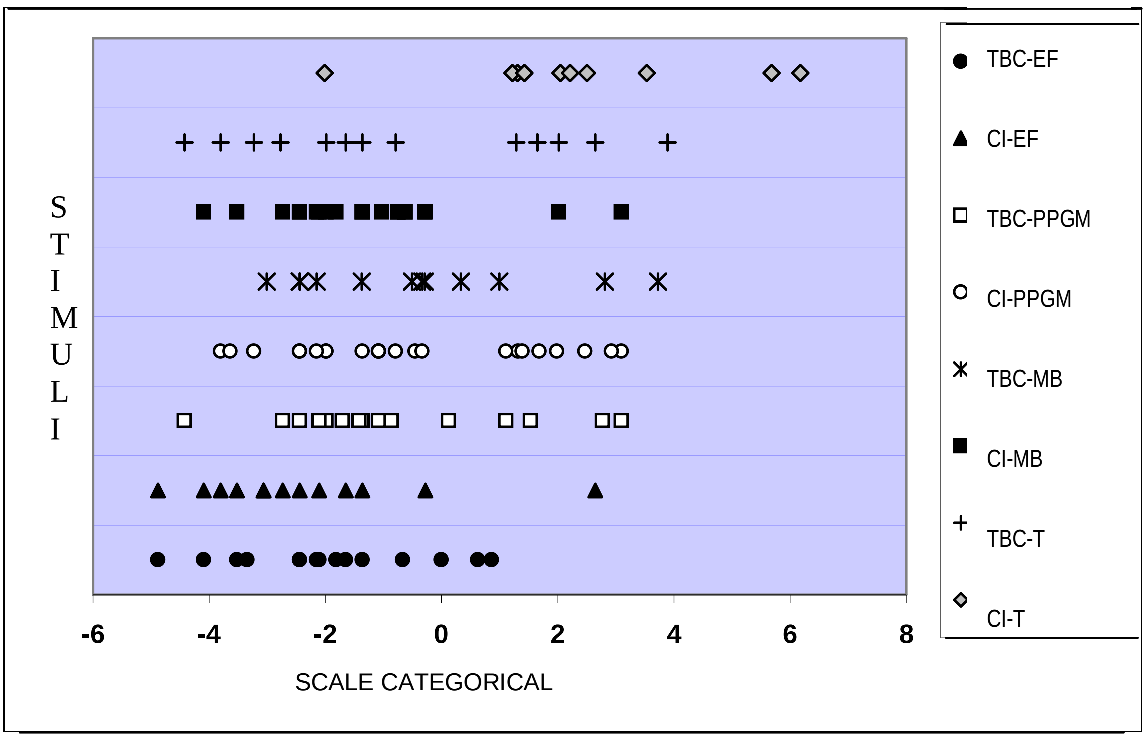


Figure 4: Variation of preferences of the decision makers – "Theoretical Foundations and Concepts" and "Context Information"

Prior to the compared analysis of knowledge, it is important to mention that the results wee extracted from the four categories of the following areas: Public Policies Government Management (PPGM), Economic and Financial (EF), Technical (T), Marketing/Business (MB).

Firstly, we established a comparison of all the theoretical bases and concepts (TBC) and context information (CI), denominated as stimulus by the areas. Thus, generally we tried from this analysis to understand the behavior of the preference intensity of the decision makers regarding stimulus. Secondly, we compared all the sets of theoretical babes, analyzing the preference intensity of the specialists regarding the theories and concepts. Thirdly, we analyzed the behavior of context information, broaching the preference intensity of the decision makers with relation to the theories and concepts. Lastly, we discussed individually the categories (areas) to understand how the theories, concepts and context information behave.

This procedure was performed with the support of the scale model of categorical judgments. With all of the various dimensions of Knowledge Objects (theoretical basis and concepts and context information), the results show (Figure 2) that there is no great predominance of another type of knowledge, and this should be considered in VCM. However, there are those with more relevancies in the decision maker's preference. Therefore, the best decision is sought, considering the background of each Supply Chain category. Furthermore, one should consider that each one has its own peculiarity, hence demanding differentiated knowledge, since we are dealing with highly subjective questions. Hence; the reason why it is wise to choose those that fit best the reality of each project of the Value Chain.

With regards to theoretical bases and concepts and context information, the "Market" category presents the following knowledge objects in an upward order of importance: (1) institutional organization for policies on VCM; (2) quality and productivity for policies on the Value Chain; (3) competitive strategy; (4) strategic planning on defense against competition; (5) administration of projects; (6) monitoring and control; (7) criteria, organization, proceeding and monitoring of projects; (8) engineering of the knowledge and technologies of the information; (9) actors; (10) risks of the project; (11) attendance the demand; (12) civil and commercial contracts; (13) productivity policy. (14) Investments policy; (15) innovation and new managing methods; (16) Financing; (17) Follow-up of costs and of supply markets of input; (19) Partnerships and Alliances; (20) Monitoring methods and techniques of the best success practices in Value Chain projects; (21) Quality Engineering – Quality Patterns; (22) Effective Engineering; (23) Technical and Human Resources; (24) Analysis of social and environmental impacts and their mitigation; (25) Information technology; (26) Indicators used by the market; (27) Monitoring the competition; (28) Profitability of the industry; and (29) New methods for forecasting and simulating the demands. The results obtained have been satisfying, validating the proceeding proposed for assembling and the prioritization of critical knowledge for VCM.

Evaluation of Knowledge's Objects using the artificial neural network (ANN) (2)

The ANN is understood to simulate the behavior of the human brain through a number of interconnected neurons. A neuron executes weighed additions for the activations of the neurons representing nonlinear relations. The ANN has the capacity to recognize and to classify standards by means of processes of learning and training. The training of the net is the phase most important for the success of the applications in neural network. The topology of the net can better be determined of subjective form, from a principle that consists of adopting the lesser intermediate number of possible layer and neurons, without compromising the precision. Thus, in this application, the layer of the entrance data possess 15 neurons corresponding the 15 variable referring to objects of knowledge. The intermediate layer possesses 7 neurons, and the exit layer possesses 1 corresponding neuron in a scale value determined for the ANN. The process of learning supervised based in the Back propagation algorithm applying software Easy NN determines the weights between the layers of entrance and intermediate, and between the intermediate and exit automatically.

The training process was finished when the weights between the connections had allowed minimizing the error of learning. For this, it was necessary to identify which configuration that would present the best resulted varying the taxes of learning and moment. After diverse configurations to have been tested, the net of that presented better resulted with tax of an equal learning 0,30 and equal moment 0,80. The data had been divided in two groups, where to each period of training one third of the data is used for training of net and the remain is applied for verification of the results.

After some topologies of net, and parameters got the network that better resulted had presented. The net was trained for attainment of two results' group for comparison of the best-determined scale for the networks. In the first test the total of the judgment of the agents was adopted, however only in as test was gotten better scales, next of represented for method of the categorical judgments. With this, the last stage of the modeling in ANN consisted of testing the data of sequential entrance or random form, this process presented resulted more satisfactory. The reached results had revealed satisfactory, emphasizing the subjective importance of scale's methods to treat questions that involve high degree of subjectivity and complexity. How much to the topologies of used networks, the results gotten of some configurations of the ANN and compared with the CJT, were observed that ANN 1, is the one that better if approached to the classification gotten for the CJT.

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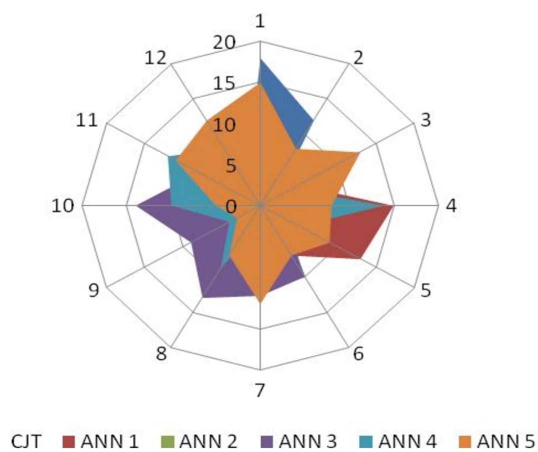

Figure 5: Priority of Knowledge's Objects - ANN and CJT

The prioritized objects for the tool proposals were for VCM knowledge. Artificial Neural Networks (ANN), as well as Psychometric (CJT), was restricted only to the specialists' decisions in projects of raised subjectivity and complexity, needing other elements that consider the learning of new knowledge. However, it is interesting to highlight that the CJT method, as it considers a variable involving a high degree of subjective and complexity and because it works with probabilities in the intensity of preferences, considers the learning of new elements of knowledge. Thus, it can be said that for typology of application, as presented here, it is sufficiently indicated. Thus, even other topologies do not Tenaha been the best ones, it had been come however close in some objects of knowledge of the CJT.

Phase 4: Determining Degree of Knowledge Evaluation – $N' = ß_1 + \Omega f\{((ß_2 DKE_1), f(ß_3 W_2)) + u_i\}$

The results generated in this phase define the modeling strategy standards in this knowledge network (innovation value chain), which will be elaborated in the next phase. The strategy modeling results from the variation between the degrees of knowledge (Desired - D and - Real - R) developed at this stage, in two steps: (i) determining DDKE – Degree of 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 product development process.

Step 1: Determining DDKE*:* The "neurofuzzy" technology will be applied to obtain DDKE (Figure 1), 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 6). These steps are detailed to follow.

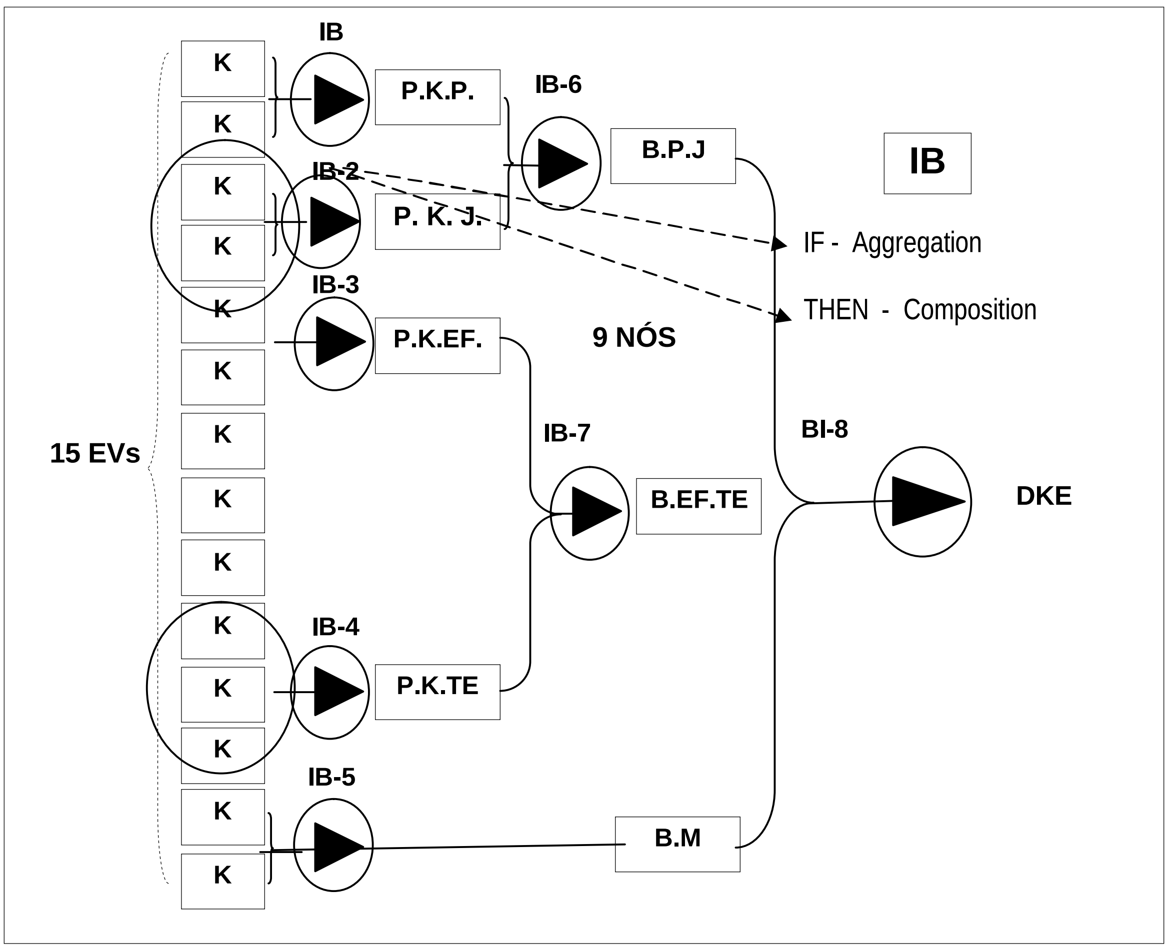

Figure 6: Neurofuzzy Model - DDKE

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. 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 in the network. This IV, then joins another IV, forming a set of new IVs, hence configurating a sequence in 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 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 (step ii), 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 (Table) to feed the input variables in this Phase and Step. For example (hypothetical), when the expert's opinion was solicited about which 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%. The Table 3 shows the "fuzzy" sets for the technical knowledge desired IV.

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											
Degrees of certainty (DoC) **(%)**	LOW	100	100	55	25	0	0	**0**	0	0	0
	MEDIUM	0	0	35	75	100	90	**55**	40	0	0
	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/TDP.

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 7.

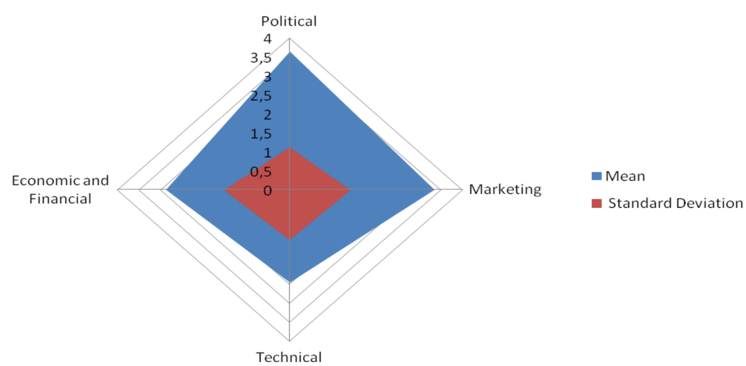

Figure 7: Mean and Standard Deviation of the knowledge- Political - P, Economic and Financial - E, Marketing - M, Technical -T

Combining the dimensions it can be stated that on average there is no predominance of one or another, with slight relevance to the economic and financial knowledge (M=3.64) (Figure 4). 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 in the PDP/TDP value chain. With the score results in this Phase, based on the specialized literature and the judges' intervention, the strategies in the knowledge networks (value chain) are defined. The procedures are detailed in the next Phase.

Phase 5: Modeling the Network Strategies (innovation value chain)

$$N' = \Omega\, f\{((\Delta DKE), f(W_n))\} \qquad N' = ß_{1} + \Omega\, (ß_2 S_n) + u_i$$

In light of the results produced in the previous phase (phase 4) and based on the state of the art, a model is proposed to identify the strategies for the product development process in a high complexity spectrum (innovation value chain) 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. However, the presence of Intelligent Agents as tools is recommended (in other applications) to facilitate understanding the environment and to perform information processing and knowledge tasks (Russel and Norvig, 1995), to perform autonomous actions and to cooperate through intelligent mechanisms in order to achieve the intended objectives (Wooldridge, 1999). For this case, the intervention of experts in the process is satisfactory, considering the not very high number of participants. As a preparatory stage towards the definition of PDP/PDT strategies, it is necessary to identify the results produced by the variation between the desired and real personal knowledge, previously defined in the PDP/TDP. 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/TDP. The intervention of experts is crucial in this process.

With the results produced by DRKE (individual) and DDKE, both before the PDP/TDP, a judgment matrix (nature of the strategies versus knowledge) is produced in phase 2, 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. In this spectrum, the knowledge strategies are prioritized to achieve satisfactory PDP/TDP results. The multicriteria analysis method was used as a decision support method. The development of strategies is structured according to the following analytical routine: Phase (i) defining the mission and purpose; Phase (ii) the structural analysis of the industry (value chain); Phase (iii) selection of elements in the strategies; Phase (iv) definition of strategies and criteria for an effective strategy; Phase (v) development of strategies to supply the PDP/PDT knowledge network in technology-based companies; Phase (IV) adjustment of preferred strategies.

The following details the results produced in these phases. Phase to define the mission, to become a benchmark in the knowledge construction of the innovation value chain in the PDP/PDT - EBTs by the integration and interaction of the individuals in a knowledge network, enabled by technology and other communication and information systems. Phase of the structural analysis of the industry (value chain), according to the determinations proposed by Porter. Applying the SWOT analysis, we have: (i) Potential Internal Strengths: (a) technological skills; (b) creative R&D management; (K) strongly differentiated product, (d) strong team of experts, especially in content, few but with high potential experts; (e) basic competence in key areas; among others. (ii) Internal Weak and Potential Points: (a) External Potential Opportunities:

(a) Potential market and investment opportunities to expand nationally and globally; (iv) Potential External Threats: Phase to select the elements in the strategies, schools, theories, other elements of the value chain innovation in PDP, from the literature and confirmed by the experts. The selection of these combined elements is then elaborated, which will help define the strategies. The strategies in the value chain in PDP/PDT to be defined later are guided by the following Schools (quoted por Mintzberg et. al., 2006): Design and Learning, focuses on dynamic capabilities; Planning, focuses on scenario analysis; Cognitive, focuses on constructivism; Environmental, focuses on contingencies; and Configuration, focuses on the process. Phase to define the strategies and criteria for an effective strategy. With the results produced in the previous phase, the following strategies were identified: (i) differentiation strategies: image, support, quality, design; (ii) customization strategies; (iii) package strategies; (iv) cognitive strategies; and (v) Learning.

In this spectrum, the following are defined as strategies: (i) image differentiation strategies, support, quality, design for: (a) environment; (b) technologies; (K) product; (d) interaction; (e) evaluation; (ii) package strategies, offer a range of products connected and integrated to form the complete package (innovative product); (iii) cognitive strategies; (iv) learning strategies; and (v) customization strategies. 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; (IV) design differentiation strategies; (vii) package strategies, in that order, respectively.

Analyzing the internal logic of these strategies, the results produced show that the main image differences relate to the environment and evaluation of results (metrics). It is also vital to create efforts for the support strategies in the interaction methods and techniques and also technologies. The product image is essential for customers, as it is observed that there is a greater chance of product rejection when it is perceived that the product is irrelevant or of little value for their needs. The evaluation must be perceived by consumers as a necessary tool and motivator in the knowledge construction process, which requires mapping during planning and defining the activities that fit each customer/client. In almost all interventions by the experts in the judging process of the strategies, most were emphatic in dealing with the dimensions interactions and motivations. However, all were unanimous in considering the set of strategies as equally important in the knowledge construction process. The challenge is to demystify the negative attitudes in the traditional methods of product development, and in this spectrum, the strategies proposed here claim to at least serve as a roadmap for planning policies in this field of product development in a broader and more collaborative spectrum than the value chain innovation.

The development of knowledge in the field of PDP has to be a collective effort of the entire multidisciplinary team. The conclusions that should be drawn from positive and negative aspects for the development of strategies means taking advantage of contributions in order to define the increasingly innovative planning policies in the field of product development in the innovation value chain. Planning models have always been driven by previously produced decisive actions, hence this logic should be maintained, by opening more space for the various strata that are understood as innovative. Specifically, the progress of constructing knowledge in the innovation value chain of the product development process should be the guidelines for a new planning policy in the innovation value chain, acknowledging that the collaborative and collective needs are best met in a diverse and innovative manner. And in this spectrum there is a need for collective and integrated planning.

Phase 6: Determining the DAKE - Conclusion of the PDP - Ex-Post

Under this proposal, an evaluation from the interaction of strategies in the knowledge network was performed (innovation value chain). This performance was operationalized by the "neurofuzzy" technology (the same procedure previously adopted for DKE), which integrates all the strategies. The result of this interaction is the degree of knowledge evaluation after the PDP/TDP - post DRKE. Here the strategic priorities are set, implemented at the end of the PDP. The adjustment of the strategies is according to the range of knowledge obtained. As an example, using designated degrees, we have the calculation of DRKEj with GdCi of the linguistic vector after the output variable DRKE, also hypothetical: (LOW=0.27; AVERAGE=0.45, HIGH=0.15). To find the numerical DRKE, the defuzzified value of the linguistic variable DRKE is found, on a 0 to1 scale. Thus, the DRKE shown is 0.6122.

Phase 7: Returning to the Modeling Function

The knowledge network results from the dynamics of the strategies in the Innovation Value Chain: N'= $\Omega f(S_n)$, produced from the variation of DKE and CSFs: N' = $\Omega f\{((\Delta DKE), f(W_n))\}$. Considering the model's characteristics of dynamism and flexibility, other variables can be added (ui). Therefore the model is better specified as follows: N' = $ß_1 + \Omega f\{((ß_2 DKE), f(ß_3 W_n)) + u_i\}$. The dependent variable (S=Y) is the result of the weighted average of the strategy samples, and the independent variables (X1=ΔDKE) and (X2=CSFS) are created from the average of the DKE variation and the average of the CSFs, respectively. These values were then subjected to a regression analysis.

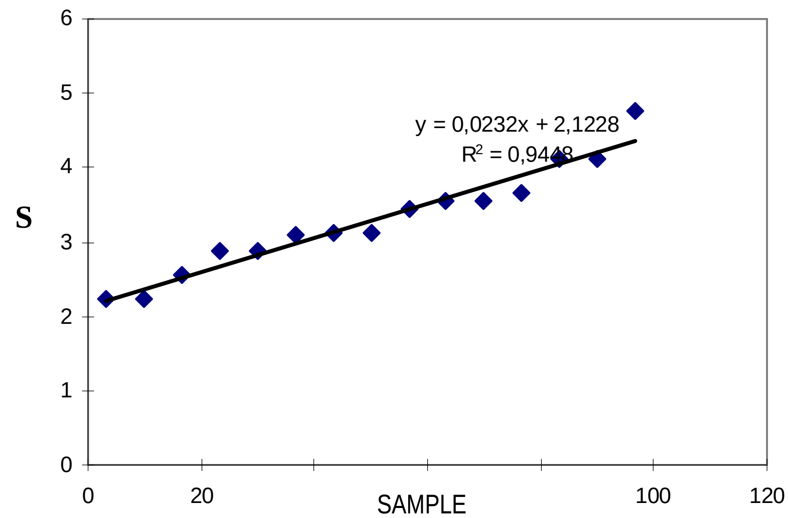

Figure 8: Linear regression of the sample based on data from the CSFs, ΔDKE and strategies

The value $ß_2$ = 0.0232 shows that when X is increased by 1%, the estimated increase of the strategies reaches 0.0232. $ß_1$ = 2.1228 indicates the average level of strategies, per actor, when the variation in the degree of knowledge evaluation is practically nil. The structural stability of the model is verified by the "F" test and confirms that the model is statistically significant, indicating that overall, the explanatory variables have a strong statistical influence on the explanatory variable. However the results produced by r^2 indicate that 94% of the variation in the average of the strategies in the innovation value chain is explained by the DKE variations and by the CSFs, indicating a satisfactory adjustment of the model, i.e., 94% of the variations in the averages of the strategies are explained by the independent variables. Increasing the average variation of DKE and CSFs by 1%, per member (actor), the average of the strategies increases by at least 0.0232 per strategy planned. And if the DKE variation is zero, and without achieving any CSFs, it will have at least 2.1228 strategies in the innovation value chain to at least keep the existing individual knowledge that is necessary to develop such product. In this spectrum, it is plausible that the actors' knowledge in the development of products/technologies is at least kept.

4. Conclusions and Implications

The study intends to fill an existing planning gap in the innovation value chain/knowledge networks in the perspective of the process of product/technology development – PDP/PDT. Thus, a model based on the definition of strategy standards in the high complexity spectrum was created, according to the Knowledge Theory. How should the structure of a reference model based on the definition of standard strategies in high-complexity spectrum of PDP/PDT be? To verify the model, a set of connected and integrated multi-methods was developed and, to demonstrate its feasibility l, a case study of technology based companies in Brazil was developed trying to look, specifically, the development process of products/technologies of these companies.

The central element of the model is the knowledge construction by the members of the multidisciplinary teams according to the products/technologies development process. This was possible by assessing the degree of knowledge evaluation of the actors in the multidisciplinary teams before and after the development of products/technologies. In other words, from the discrepancies found between the actors' real knowledge (existing) and desired knowledge (actors) to develop products/technologies a set of strategies was proposed to address such discrepancy between real and desired knowledge. Therefore, the construction of knowledge is developed in light of the strategies. This procedure was possible using a hybrid intelligent architecture that combines artificial neural networks and the fuzzy logic. This technology proved suitable to contribute to the robustness of the model and the results achieved. Also, it underscores the importance of the neurofuzzy. Technology acknowledged as an additional managing instrument at the hands of administrators, particularly for the matter at hand, which enabled to identify the Degree of Effectivity of Knowledge Priority Decision in the Value Chain. This requires a more attentive outlook to questions involving the external environment. Neurofuzzy technology has been applied to support the decision making process in problems that involve subjective and objective attributes. A Neurofuzzy model was structured and the result was designated Degree of Mode Effectiveness, representing the level of adequacy of the mode option to the manager's needs. The results obtained with the application of the proposed model show that this technology is adequate for supporting decision-making, mainly due to its low level of complexity and to its flexibility, which allows the input and output of variables.

Thus, the main objective proposed was to draw attention to the relevance and opportunity to refine efficiency and innovation in planning. Therefore, a reference model was designed for standard strategies in a highly complex spectrum/knowledge network to evaluate the different degrees of knowledge in PDP/PDT. With the models and international experiences, the best and worst practices enable to discuss this reference model in a plausible and feasible manner. Of course many questions remain to be further developed in other studies of this nature and we hope to have contributed to a plausible methodological discussion, but which can still be more explored. It is important to understand the PDP/PDT in the innovation value chain considering that the needs of the different strata of society are best served when handled collectively and collaboratively. 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 construction 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 development of products/technologies in the value chain. The model is a valuable conceptual tool. There are many challenges that permeate PDP/PDT in the innovation value chain, particularly given the efficient and effective instruments, methods, techniques and methodologies that are useful in planning, and which are subject to the insulated inefficiency by rigid standards that stifle the essence of the innovative and flexible nature that should adapt to PDP/PDT. The literature has difficulty when addressing this subject, this planning stage is often devoid of effective and appropriate instruments. But it is also true that making use of "ready-made" has resulted in the managers of product development/technology to indefinitely postpone the process of reorganizing this segment.

The framework proposed requires the development of formal models to better describe and rationalize the evaluation of strategies, based on best practices in innovation, in which mathematical models are not sufficient to describe situations of complex applications. Experience and human intuition are important in decision processes that require high tolerance for ambiguity. Human experience and intuition are important in decision processes that require high tolerance for ambiguity. The proper use of complex decisions in PDP/PDT requires applying specifically designed methodologies that are in agreement with the particularities of each product development project. What is strongly assumed is the fact of recognizing the importance of subjectivity in the decision makers' judgment; their values, their objectives, their biases, their culture, their intuition, as well as the influence of the subjective perception and the understanding of the knowledge available.

Here the modeling approach presented gains emphasis, the psychometric methods and artificial intelligence systems such as the "fuzzy" logic and neural networks, which when combined are valuable tools with great potential and large-scale added value, contributing to the robustness of the model. It is also recognized that the use of only one method is often seen as a gross simplification, without adequately reflecting the study object. Then, with this proposal, a reliable, valid, legitimate instrument is sought, one that is capable of evaluating strategies in a high complexity spectrum, based on the intended objectives for each Phase, interpreted from the previous phases and towards the model's intended goal.

It is believed that the failed attempts of the traditional product development methods gain way to reinforce the importance of their role, taking a leap towards more innovative and risk-free models. This does not replace the absolute power control of the activities and actions and also does not disregard what has thus far worked, but rather encourages pragmatism to responsibly implement PDP/PDT. Moreover, the process of building an innovative product development opens a new attribute for the relationship between the actors of multidisciplinary teams in the value chain in the product development process – PDP/Process Development Technology – PDT. Considering the traditional practices, it should be noted that, somehow, with all its limitations, managers have tried, in their own way, to face the challenges in the product development/technology. It is also true that this is a general discourse on the development of a model, which may sound rhetorical and somewhat inappropriate for an analytical work.

The approach here is not intended to unconditionally replace the allegedly inefficient models, but rather to value them, enriching them with technical, procedural and managerial advantages. However, these results must be evaluated objectively, based on an advantage indicator of an innovative model given the traditional approaches. With regards to procedures, this proposal also aims to draw attention to:

i. renew the classical model to develop products with creative and sophisticated elements and procedures, which would replace the merely technocratic methods and traditional techniques;
ii. adopt decision support methods, as shown and demonstrated throughout this model, analysis and evaluation, which are better suited to deal with the complexity and subjectivity of the result impacts;
iii. a procedure, that is, a set of adjusted procedures, supported by instruments for legitimacy, validity and reliability of the proposal presented.

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/PDT, 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.

Also in this effort, these research priorities of knowledge construction should be permanently and periodically applied. Finally, this study has a solid basis for the continuation of other studies, overcoming unscientific practices that still permeate this object, thus more pragmatic and effective guidelines to subsidize the development of new products in the long term.

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.

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