Multi-Model To Assess The Impact Of Knowledge On The High Complexity Environment Performance In The Product Development Process Under Uncertainty And Unpredictability

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Abstract

This work intends to contribute to the planning guidelines in the field of high complexity environments. Thus, it develops a modeling proposal to assess the impact of knowledge on the innovation value chain performance in the product development process (PDP) under uncertainty and unpredictability, that considers a sequence of systematic procedures in the following phases: Phase 1: Modeling the needs of information in innovation value chain under uncertainty and unpredictability. Phase 2: Modeling for the determination of the critical Stakeholders' knowledge in innovation value chain under Uncertainty and Unpredictability. This research treated Brazil's high-tech industries as the empirical targets. Several support instruments were used in the modeling elaboration in order to reduce subjectivity in the results: psychometric scales - Thurstone*'s* Law of Comparative Judgment (LCJ), multi-criteria Compromise Programming, Electre III, and Promethee II; Artificial Neural Networks (ANN); Neuro-Fuzzy Intelligence. The results produced are satisfactory, validating the proposed procedure for Innovation Value Chain.

Keywords: Modeling; Assess the Impact of Knowledge; High Complexity Environment Performance; PDP

I INTRODUÇÃO

Recently, relevant changes have made organizational boundaries more fluid and dynamic in response to the rapid pace of knowledge diffusion [1]; [2]; [3], innovation and international competition [4]. Such changes have helped to reconsider how to succeed with innovation [5]; [3]; [6]. Thus, innovative companies make use of their capabilities to appropriate the economic value generated from their knowledge and innovations [2];[3]. Therefore, the Value of innovative products is presented as a quality standard in the race for pressing demands. In fact, a new product or process can represent the end of a series of knowledge initiatives and the beginning of a value creation process, 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 [7]. Knowledge can lead to performance improvement of other co-related or co-located companies. Moreover, innovations are the incremental results produced by the interactive process of the knowledge that is generated, disseminated and applied to the various links in the innovation value chain [8]; [9]; [10].

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. The characteristics of the value chain differ a great deal, therefore becoming the object of analysis equally differentiated. Many times the projects are made impracticable still in the act of planning, hence becoming unsustainable. One of the aspects that deserves to be highlighted is the occurrence of errors in the management of the value chain, which often results in a non-fulfillment of the established goals and performance. It is imposed thus that the efficiency in the planning of the value chain propitiates more efficient decisions, diminishing the improvisation and improvement of the involved team.

Traditionally, the planning phase "sins" when it is elaborated without support of the knowledge that really is essential in the management of the innovation value chain. Therefore, a support system for the decision of the building up and the Value Chain Management has been developed based on the methodological support of the Knowledge Management (KM) Theory. The aforementioned system considers a sequence of proceedings directed to the prioritization ranking of knowledge objects, so to assist managers to choose priorities regarding information and theoretical knowledge in the Value Chain Management. This contribution focuses on the definition of knowledge priorities. On the bases of a methodological strategy explained further on, which included interviews with Brazilian specialists in Value Chain Management, the priorities have been systemized and prioritized. It is within this panorama that the methodological contribution of this Value Chain gets emphasis, as there is a support to the critical priorities to be considered in the list of necessary elements for the Value Chain Management of this nature. In synthesi, This work intends to contribute to the planning guidelines in the field of high complexity environments.

Thus, it develops a multi-model proposal to assess the impact of knowledge on the innovation value chain performance in the product development process (PDP) under uncertainty and unpredictability, that considers a sequence of systematic procedures in the following phases: Phase 1: Modeling the needs of information in innovation value chain under uncertainty and unpredictability. This phase is structured in two stages: stage 1: identification of CSF; Stage 2: evaluation of critical success factors, and stage 3: Prioritization of the information needs starting from the crossing of CSF and the Areas of Information in innovation value chain. Phase 2: Modeling for the determination of the critical Stakeholders' knowledge in innovation value chain under Uncertainty and Unpredictability. This phase has been subdivided as follows: Stage 1 - Identification and Acquisition of Knowledge in innovation value chain in PDP; Stage 2 - Knowledge impact evaluation on the innovation value chain performance in PDP using the Artificial Neural Network (ANN); Stage 3 Representation of knowledge in mental maps; and Stage 4: Determination of the effective rate of knowledge priority on innovation value chain performance using Neuro-Fuzzy intelligence. This research treated Brazil's high-tech industries as the empirical targets. Thus, this work is systematized in the following sections: 1 – Research Design, 2 – Modeling and Underlying Analysis, and lastly, the conclusions and implications. These different phases and stages are detailed here.

II. RESEARCH DESIGN

This phase is structured in two stages: Stage 2.1) determination of the conceptual model and hypothesis; stage 2.2) determination of the Sample and Data Collection.

Constructs and hypothesis

This section details the elements that comprise the conceptual model and hypothesis used in the study. Thus, the stakeholders' knowledge (sources) from diverse backgrounds and scenarios and specialized literature. This section examines the Conceptual Model of the Study (Figure 1):

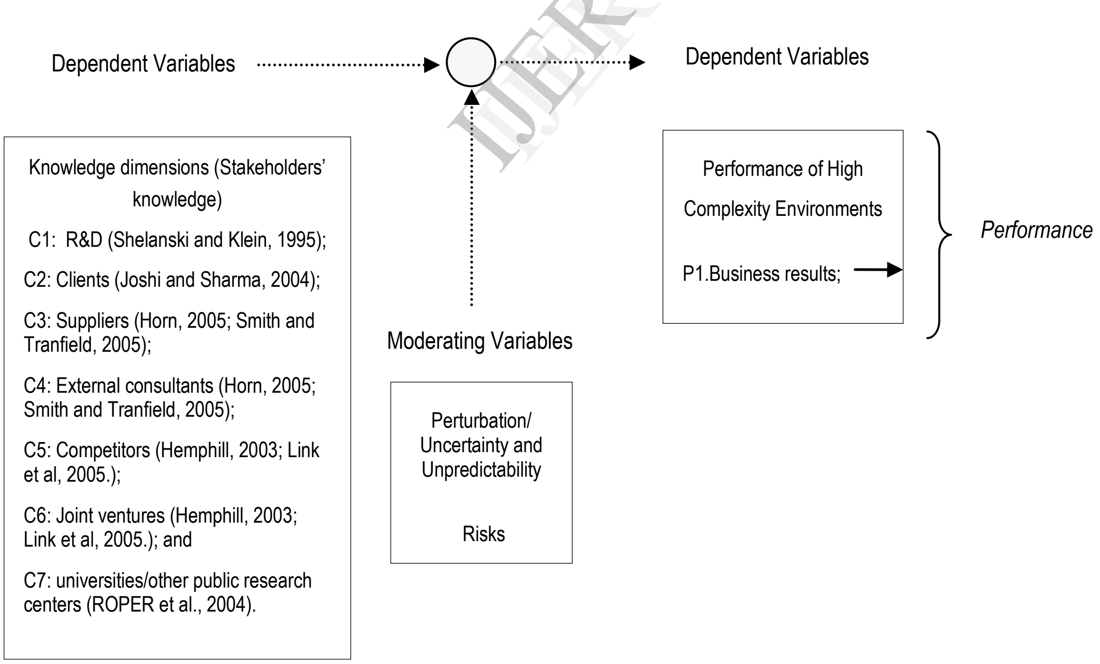

Fig. 1: Conceptual Model

Here, following the proposals of [11], knowledge is considered as the elaborated, refined information, which is also able to self-evaluate its liability, relevance and importance. Thus, the hypotheses are:

Dependent variables: the following dependent variables were selected for this research: Impact on the Value Chain performance.

Independent Variables: The independent variables were extracted from the specialized literature and assessed by experts for confirmation. The following independent variables were identified: Stakeholders' knowledge: K1:

R&D [12]; K2: Customers [13]; K3: Suppliers [14]; K4: External consultants [14]; K5: Competitors [15]; K6: Joint ventures [15]; and K7: universities/other public research centers [16]. For the Customer dimension, the construction used is based on [13]. For the R&D variable, the construct was mainly derived from [12], which capture two important R&D aspects: capabilities and connections. The variable Competitors is based on [15]. Finally, the variable Joint Ventures is based on [15]. 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. The result has allowed defining four groups that represent the groups of knowledge: D1 - Market; D2 - Political / Judicial; D3 - Economical and Financial; and D4 - Technical Factor.

Moderating Variables: The moderator or controls variables are the risks. In a risk situation, future events have probable outcomes [17]. Uncertainty with regards to risk is a condition that renders difficult to predict the likelihood of various future events [17]. It is believed that the presence of risks can increase the positive effects of the stakeholders' knowledge impact on the innovation value chain performance in the PDP. Additionally, an environment of uncertainty can weaken the influence of knowledge on the performance of innovation value chain. In an environment of unpredictability and unexpected change these variations or disturbances can make the results highly subjective.

Independent variables: Once it is validated that the performance of innovation value chain in the product development process contains multifaceted aspects, a construct is used to measure the performance of the innovation value chain in the PDP. The following hypotheses were formulated using the conceptual model: *Hypothesis 1:* The knowledge have positive impact on the innovation value chain performance *H2:* The effective rate of knowledge priority on innovation value chain performance depends of the interaction of the Stakeholders' knowledge.

II. MODELING AND UNDERLYING ANALYSIS

The building-up and the management of a Value Chain require highly complex analytical approaches, which include subjective elements. Thus they demand the technical mastery of various technological, human, environmental, technical, legal, financial and political aspects and procedures. Knowledge Management may represent a strategic tool, increasing the institutional capacity of the Entrepreneurs in their assignments of formulation, evaluation and execution of such projects [18]. The KM would work as a facilitator instrument of improvement, contributing for the quality of services and the enhancement of the agility to decide. The current proposal to build up a methodological support applied to the VCM happens within the following proceedings: we start by modeling the needs of information required to feed various activities developed (by the areas of information) in the build-up and the management of VCM projects, which will be developed starting from the Critical Factors of Success, that will be identified and evaluated. The Method of Critical Factors of Success is the most used to determine the needs of information in businesses. In order to identify and to set priorities for information needs in VCM projects, following steps are foreseen: stage 1) determination of Critical Success Factors; stage 2) determination of the information areas; and stage 3) prioritization of the information needs starting from the crossing of CSF and the Areas of Information. These different stages are detailed here.

Phase 1: Modeling the needs of information in innovation value chain under Uncertainty and Unpredictability

This phase is structured in three stages: Stage 1) determination of the Critical Success Factors (CSF); stage 2) determination of the information areas; and stage 3) prioritization of the information needs starting from the crossing of CSF and the Areas of Information.

Stage 1: Determination of CSF: This phase 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: (a) environmental analysis (external variable: political, economical, legislation, technology and 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. (B) CSF Evaluation: After their identification, the CSF is evaluated in order to establish a ranking by relevance. Here the scale model of categorical judgments designed by [19] has been adopted. Thus, the evaluation of the CFS is systematized in the following steps: Step 1: determination of the frequencies by pairs of stimuli. Step 2: determination of the frequencies of ordinal categories. Step 3: calculation of the matrix [πij] of the relative frequencies accumulated. It is highlighted though that the results to be achieved in Step 3 reflect the probabilities of the intensity of the specialists' preferences regarding the stimuli, the Critical Factors of Success in this work. As a result, a hierarchical structure of CSF is obtained. Determining the CSF is the goal, according to [24], the CSF in VCM are: first, the Market and Political Factors; second, the Technical Factor; third, the Economical and Financial

Factor; and fourth, the Judicial Factor. Assembling here the many dimensions of the CFSs, the results show that there are Political and Market factors-predominance. This is seen when taking into account the relevancy of public policies for the design of VCM.

Stage 2:Determination of the Areas of Information: The CSF having already been defined, the information areas are delimited with respect to the different CSFs. After determining the CSF, the determination of the areas of information ensues. The result has allowed defining four groups that represent the areas of information: first, the Governmental Area on Public Policies; second, the Economical and Financial Area; third, the Technical Information Area; fourth, the Market Area. The goals of the areas of information define specifically what must be achieved by these areas to meet one or more objectives from the projects (business), contributing for the enhancement of the project performance as to quality, productivity and profitability.

Stage 3: Prioritization of the information needs starting from the crossing of CSF and the Areas of Information: Again, these information areas are ranked by application of the same Categorical Judgment Method of [19] 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 ™. These methods rendered their contributions in determining the performance in the areas of information, which led to the identification of Mercadology Area as the most important ones in order to globally ensure the overall critical success factors. The critical knowledge for VCM is determined in the sequence.

Phase 2: Modeling for the determination of the critical Stakeholders' knowledge in innovation value chain under Uncertainty and Unpredictability

This phase has been subdivided as follows: Stage 1 - Identification and Acquisition of Knowledge in innovation value chain in PDP; Stage 2 - Knowledge Impact Evaluation on the innovation value chain performance in PDP using the Artificial Neural Network (ANN); Stage 3 Representation of Knowledge in Mental Maps; and Stage 4: Determination of the effective rate of knowledge priority on innovation value chain performance using Neuro-Fuzzy intelligence. This proceeding is shown in details as to its structure.

Stage 1: Identification and Acquisition of Knowledge: Initially, information topics which have been already identified will be elaborated, analyzed and evaluated in order to be understood by the decision makers during the formulation and the VCM. Following this, they will be reviewed and organized and validated by VCM specialists. Afterwards, relevant theories and concepts are determined. With respect to the acquisition procedures, the different procedures of the process of acquisition represents the acquisition of the necessary knowledge, abilities and experiences to create and maintain the essential experiences and areas of information selected and mapped out [20]; [21] . Acquiring the knowledge (from specialists) implies, according to [22]; [23], the obtaining of information from specialists and/or from documented 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 VCM. First the information is gathered. Then the combination and internalization is established by the explicit knowledge (information) so that it can be better understood and synthesized in order to be easily and quickly presented whenever possible (the information must be useful for the decision making and for that reason, it must be understood). In this work, we aim to elaborate the conversion of information into knowledge.

The conversion (transformation) takes place as follows: first, the comparison of how the information related to a given situation can be compared to other known situations is established; second, the implications brought about by the information for the decision making are analyzed and evaluated; third, the relation between new knowledge and that accumulated is established; fourth, what the decision makers expect from the information is checked. The conversion of information into knowledge is assisted by the information maps (elaborated in the previous phase by areas, through analysis and evaluation of the information). We highlight that the information taken into account is both the ones externally and internally originated. The information from external origins has as a main goal to detect, beforehand, the long-term opportunities for the project [23]. 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 VCM projects are identified. In other words, which knowledge and theory are required to be known in order to ensure the success of projects on Value Chain in that Area. Then, the analysis of surveys in institutions about the job market for these institutions takes place bearing in mind the demands of similar areas studied in this work. As for the offer, we intend to search for the level of knowledge required by the companies and other organizations in those areas, as well as what concerns technical improvement (means) for the professionals. This stage determines the concept of knowledge to be taken into account on the development of this work. So, for the operational goals of this work, we have adopted them as the “contextual information” and the theoretical bases and concepts. The result has allowed defining four groups that represent the knowledge for Value Chain Management: Market Knowledge; the Governmental Public Policies Knowledge; Economical and Financial Knowledge; and Technical knowledge.

Stage 2 - Knowledge Evaluation Using Artificial Neural Network (ANN)

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

Evaluation of Knowledge’s Objects using the artificial neural network (ANN): 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 0,55 and equal moment 0,95. 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. This result confirms the hypothesis H1: The knowledge have positive impact on the Value Chain performance.

Stage 3: Mental Representation of the objects of knowledge in cognitive maps

After prioritizing the objects of knowledge, the build-up of cognitive maps take place (Market Area), assisted by the software Statistics. In order to create maps, the denominations of the objects of knowledge have been abbreviated. The results of the decision makers’ intensity about the objects of knowledge can be seen in Figures 2, 3, and 4.

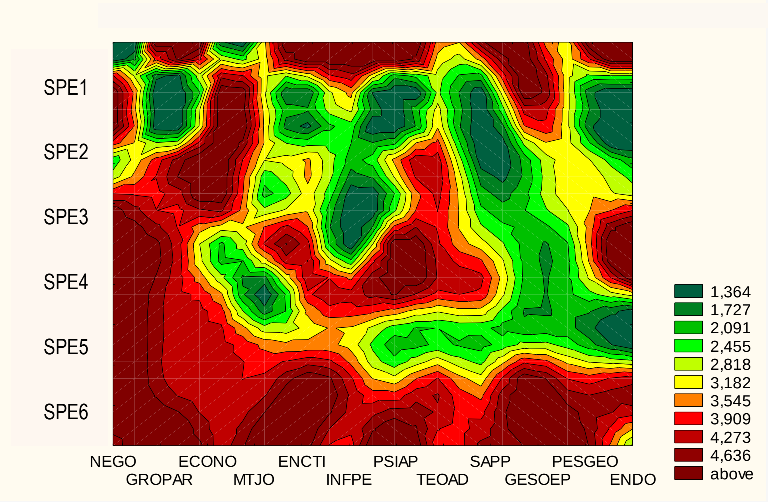

Fig. 2: Mental Representation of the objects of Knowledge in Cognitive Maps – Segregation Basis, Theories and Mercadology Concepts- Business

Before anything else, it is worth emphasizing that the logistic managing is viewed from a strategic perspective, planning and coordinating the necessary activities, in order to meet the desired levels of services and quality at the lowest possible costs. By assembling the vast dimensions of knowledge, there is a prevalence of "the best managing practices of Value Chain projects" (NEGO), "Economy" (ECONO) and "Risk Managing" (GROPAR). Unified to this there is the know-how of partnerships and alliances, quality and productivity

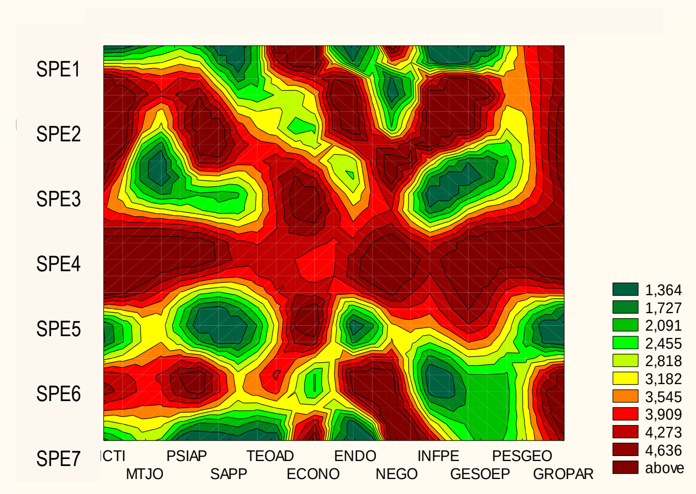

Fig. 3: Mental Representation of the objects of Knowledge in Cognitive Maps – Segregation Basis, Theories and Mercadology Concepts- Business

The challenge that appears in the Value Chain managing is the result of a good practice: (I) shorten the logistic flux; (II) improve view of the logistic flux; (III) consider logistic managing as a system. Such practices direct towards planning, managing and control of the logistic operations by means of monitoring the documented performance of the logistic system, which includes: (I) service levels and the components of logistic costs; (II) control strategies that continuously follow the performance and are used to upgrade the logistic process to place it in conformity when it exceeds control patterns and; (III) control routing that are projected to motivate employees, including additional payment practices for productivity.

Also emphasized is that efficient Value Chain managing perceives, first of all, allying costs and adequate service levels to clients, assurance of compensatory policies on losses and benefits, establish a rational stock policy and appropriate modals in agreement with costs availability, storing (deposits), productive plants and productive capacity, automated production system or not, and distribution centers. In all, good managing practices are grounded on monitoring guidelines related to storing types and location; sources and levels of stock; purchasing principles; transport requirements; methods for handling material; and basic methods for processing orders. With regards to risk management, this work considers as information the methods and organized processes to reduce losses and increase benefits in order to substantiate the strategic objectives. This requires identifying the risks, quantifying risks, selecting risks, decide (avoid or transfer) risks, inform and communicate and follow-up risks completely, exactly, updated and well-timed. With regards to the processes, here are some of the risks: (i) on efficiency; to meet or not efficiency – to have, or not, the quality and integrity, as for instance, incomplete information and processes; (ii) risks related to the scale capacity and economy, as for instance, idle machine capacity, company equipment and sectors; (iv) risks related to standardization, concentration or diversification, for example, products are distributed nationwide (costs may reduce) or can be diversified regionally (costs are higher with additional expenses), future cash flow placed under liabilities due to exchange rate variation; (v) risks related to bottleneck, redundancies, discontinuity and looping, for instance, greater entries than processing capacity, data bank creation with incomplete information; and limits, e.g., minimum risk limits: stocks and processing. With regards to economical aspects, it is worth emphasizing the econometric models, which have been used very much lately in situations including parameters estimations that pertain to relations constructed by the economical theory, as well as hypotheses formulations regarding the behavior of reality as instruments. Figure 4 depicts the results of the context information from the Market Knowledge.

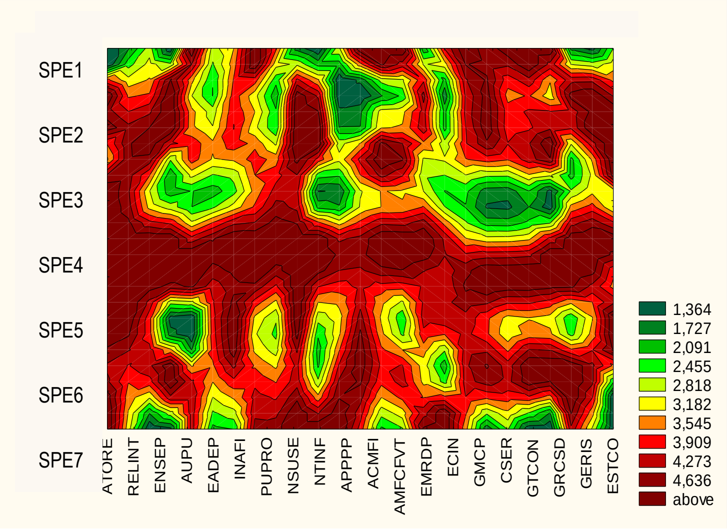

Fig. 4: Mental Representation of the objects of Knowledge in Cognitive Maps – Context Market Information – Business

It is relevant to emphasize the knowledge dimensions about the "actors in the VCM projects sector" (ATORE) and "International Relations". The role of the economic questions stands out (macro and micro), fiscal, investments, interest, financing, costs structure, product price, competition, among others that exert direct or indirect repercussions in the Value Chain decisions (ECONO). Also recognized is the importance of "managing the relationship of partners and alliances" (GROPAR). There is a subtle homogeneousness of these cognitive elements in the Value Chain Management. Time, delivery time, technical assistance and prompt delivery become fundamental. These elements are a priority given that to reach new markets and improvement in geographic integration, managing goes beyond the traditional economic activities; which takes place through partnerships with potential clients, suppliers, competitors, knowledge and technology, raw materials, innovations and the pursuit for better practices. Moreover, the current market complexity demands that the managing efficacy of product flux surpass the limits from local to global. Within this spectrum, logistics is viewed as a strategic area that enables companies to expand their relationships in the international market, transposing geographic and economic hurdles.

Stage 4 – Determination of the effective rate of knowledge (ERK) priority on innovation value chain performance Using Neuro-Fuzzy Intelligence

This stage focuses on determining of the effective rate of knowledge priority on innovation value chain performance Using Neuro-Fuzzy Intelligence. Seeing that it is a process whose attributes mostly have characteristics of subjectivity and the experience of the decision-maker is quite significant, there is a need for a tool that allows the association of quantitative and qualitative variables converged to a single evaluation parameter [24]; [25]; [26]. This model (Figure 5) adds the technology of neural networks to the fuzzy logic (neuro-fuzzy intelligence).

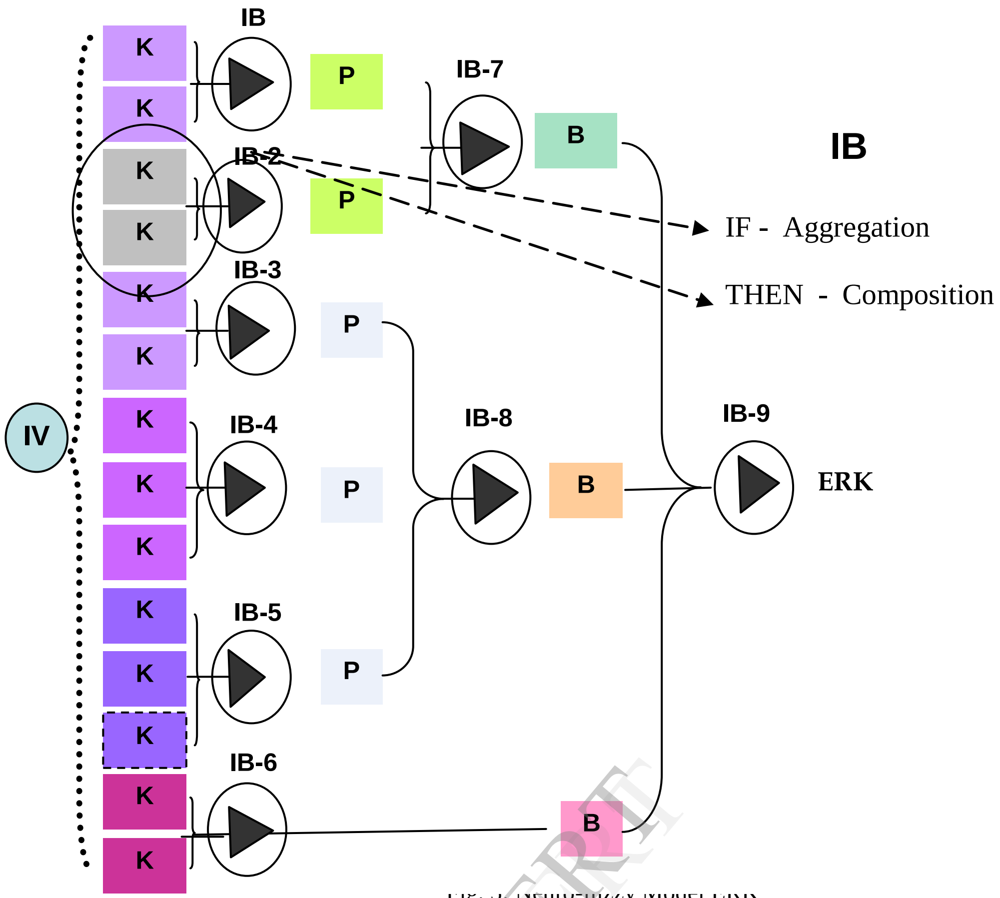

Fig. 3. Neuro-fuzzy Model ERK

The model captures uncertainties and imprecision in high complexity environments. Here, this model supports the Value Chain Managing and is adapted from the model of [24]. In such neuro-fuzzy intelligence, the entry data can be quantitative and qualitative and are grouped to determine the comparison parameters between the alternatives. Since the exact models suitable for this type of calculation have a complex application, the neuro-fuzzy intelligence enables and simplifies the human decision of reproducing the process. This modeling is structured from a combination of all of the attributes in blocks of inference that use base fuzzy rules and linguistic expressions, so that the preference for each alternative of knowledge priority decision, in terms of benefits in Value Chain, can be expressed by means of a "grade" varying from 0 to 10. Within this spectrum, this stage presents a modeling to evaluate objects of knowledge to provide support to the Value Chain Performance, based on quantitative information and also on the specialist's qualitative information, using the neuro-fuzzy intelligence. The qualitative parameters are difficult to measure and may indicate high levels of subjectivity, hence justifying the application of methods that allow the convergence of these parameters to a single coefficient, therefore enabling the decision-making taking into account all of the relevant attributes. The stages of the model are described to follow:

Stage 3.1: Determination of the Entry Variables and Linguistic Terms

It focuses on determining the entry variables (EV). These variables are categorized according to the quantitative or qualitative types. Also, the linguistic terms attributed to each EV are presented: High, Medium and Low. Thus, the EVs (knowledge - theoretical bases and concepts and context information: *first*, Market (M) Knowledge; *second*, the Governmental Public Policies Knowledge; (GPP); *third*, the Economical and Financial (EF) Knowledge*; fourth*, Technical Knowledge (T)) shown in the Modeling are (Phase 2 – Stage 1). Guidelines of: investments; risks; environmental; risks; regulations – legislation; client service/quality; quality; productivity; costs structure; best quality engineering and VCM; financial result; productivity practices, market risk; competitive strategy; criteria, organization, proceeding and monitoring of projects; actors; technology transfer and commercialization; negotiation, best practice in Value Chain management; partnerships and alliances; economy; risks of project; new technologies; issues economics; technological innovation processes; meet demand; competition; Value Chain risks; project uncertainty; political risk; innovation and new managing methods (demand and offer); follow-up of Value markets of input; offer and demand of human resources; cash flow; financial engineering; effective engineering; technical and human resources (offer and demand); capital structure; taxes, analysis of social and environmental impacts and their mitigation; Information technology (Best Practices); Indicators practiced by the market; and monitoring the competition, among others. After their identification, the theoretical bases and concepts and context information (knowledge) were evaluated in order to establish a ranking by relevance. Here the scale model of categorical judgments designed by [19] has been adopted (Phase 2, Stage 1). These variables were extracted (15 variables/classification) from the independent variables.

Stage 3. 2: Determination of the Intermediary Variables and Linguistic Terms

The entry variables go through the process of fuzzy inference, resulting in linguistic terms of Intermediary Variables (IV). Thus, the linguistic terms attributed to the IV were: Low, Medium and High, including some variables: Slow, Moderate, Fast – Bad, Regular and Good. The extracted intermediary variables were: Political Performance; Economic and Financial Performance; Market Performance; and Technical Performance. CONFIGURATION Technical - Mercadology Benefit – (RDE). The proposed design is made up of seven configurations of fuzzy specialist systems, two entry variables (EV) that go through the fuzzy process and through the inference block, therefore producing an exit variable (EXV), designated intermediary variable (DV). In turn, such DV joins with another DV, hence forming a set of new EVs, consequently configuring a sequence until the last layer of the network. In the last layer, the definite variable EXV of the neuro-fuzzy modeling is produced. This EXV then undergoes a de-fuzzing process to achieve the final result: the Value Chain decision (RDE).

Stage 3.3: Determination of the Exit Variable – Effective Rate of Knowledge Priority on the innovation value chain performance Using Neuro-Fuzzy Intelligence

The Exit Variable (EXV) of the neuro-fuzzy model proposed was denominated effective rate of knowledge priority on the innovation value chain performance , resulting in the processes of:

Fuzzyfication: This process includes determining the functions for each of the entry variables. If the entry data, the calculation results and observations are precise values, then it is necessary to perform the structuring of the fuzzy arrangement for the entry variables, which consists of the fuzzyfication process. In case the entry variables are obtained in linguistic values then the fuzzification process is not necessary [25]. The fuzzy arrangements can be characterized as a generalization of the Boolean sets, where the pertinency function can assume values at fixed intervals. Usually, the interval [0,1] is considered, when it is not correct to assume that an element belongs to a specified set, but that it does indeed present a certain degree of pertinency. Therefore, a 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 pertinency (or degree of pertinency) of x in A and is defined as the mapping of X in the closed interval [0,1], in agreement with a Equation 2 [27].

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

Fuzzy inference: The ground rules of fuzzy inference is made up of the IF-THEN type, which are responsible for the association of the entry variables and the generation of the exit variables in linguistc terms, with their respective pertinency functions. The fuzzy inference is structured by two components: (i) aggregation, which means the computing from the SE of the rules; and (ii) composition, regarding the THEN part of the rules. The Degrees of certainty (DoC) that determine the linguistic vectors resulting from the processes of aggregation and composition are defined by the Equation 3.

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

Defuzzification: In some applications the interpretation of a result is enough, as for instance, when a qualitative or verbal response is desired. However, in other applications, a numeric value as a result from the system is deemed as necessary (as for instance, arrangement and comparison). In these cases, after the fuzzy inference, a defuzzification process is necessary, that is, transform the linguistic values from their pertinency [26] functions. Usually, the Maximum Center method to determine an exact value for the Exit Variable linguistic vector is used. From this method, the certainty degree of the linguistic degrees are 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 pertinency functions), in agreement with the definition of the Equation [26]. Where DoC represent the degrees of certainty of the linguistic terms of the final exit variable and X indicates the typical values for the linguistic terms that correspond to the maximums of the fuzzy sets, which define the final exit variable.

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

The results can be seen in Figure 8, extracted from the neuro-fuzzy model, which associates the EVs with its intermediary and exit layers, by means of inference blocks, where the inference rules for each pair of the considered variables are contained.

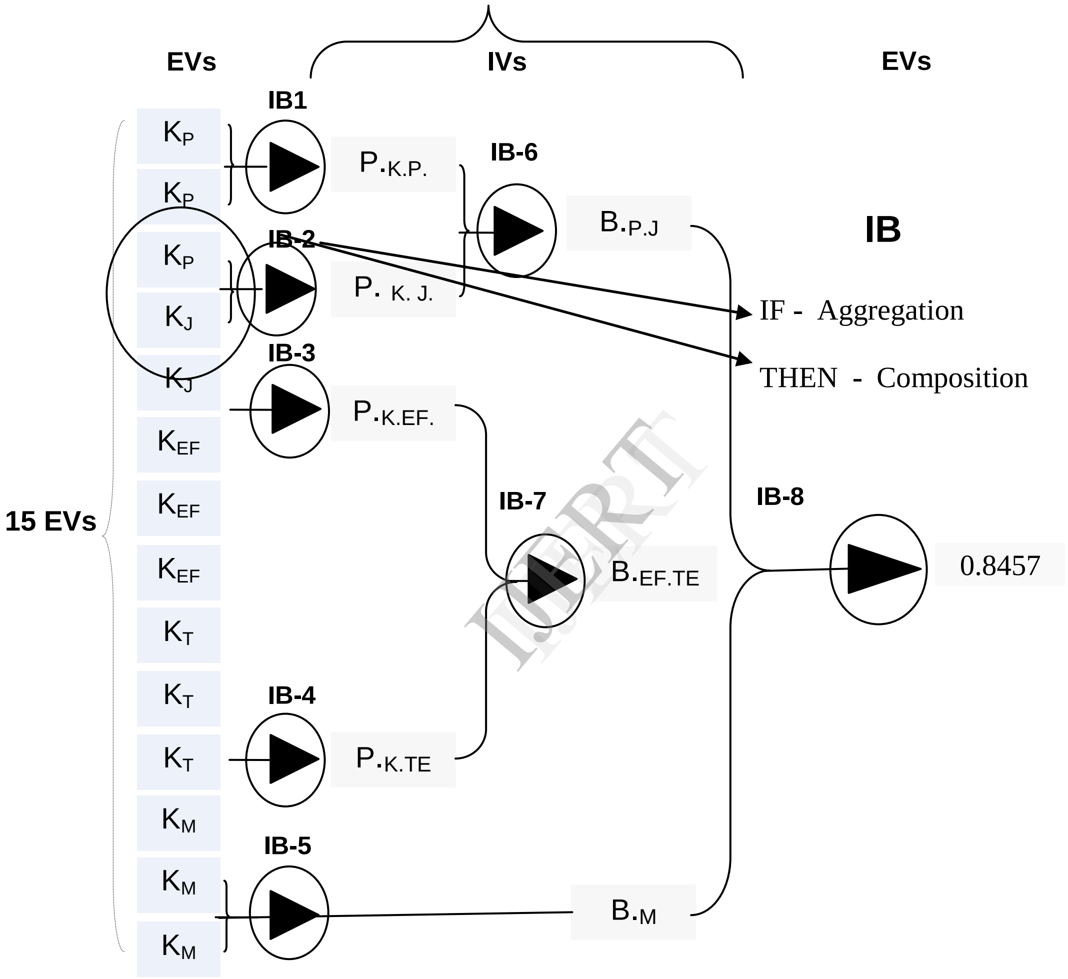

Fig. 6: Neurofuzzy Model

The result of the implementation (EVs – Knowledge – Political,,Economic and Financial, Market, and Technical) is the (RDE), defined between 0 and 10, in an increasing scale according to the adequate decision-making on knowledge in the Value Chain managing, regarding benefits for performance. The effective rate of knowledge priority in decision and performance of the Value Chain is 0.8457 (Figure 8). This result confirms the hypothesis *H2:* The effective rate of knowledge priority on innovation value chain performance depends of the interaction of the Stakeholders' knowledge. The result of each implementation is the (ERK), defined between 0 and 10, in an increasing scale according to the adequate decision-making on knowledge in the Value Chain Managing, regarding benefits for performance. The effectives rates of knowledge priorities in decision and performance of the Value Chain are: Political – 0,8956; Market – 0,7992; Economic and Financial – 0,6521; and Technical – 0,5217 (Figure 7).

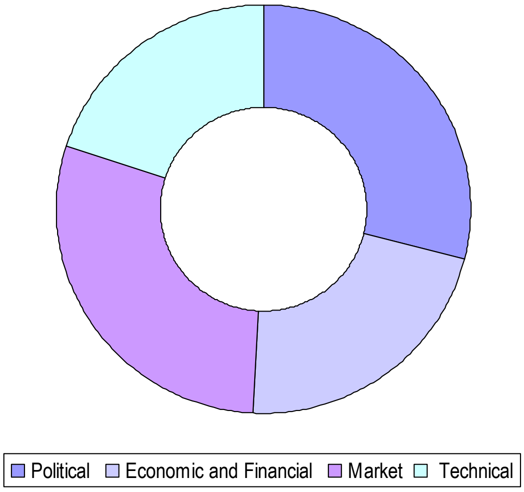

Figure 7: Degree of Effective Rate of Knowledge (ERK) Priority on the innovation value chain performance Using Neuro-Fuzzy Intelligence

The (RDE) indicates choosing the best alternative to concentrate the endeavors on the Value Chain managing. Meaning, that at first sight, it is vital to focus on monitoring the external ambient (Market and Politics), afterwards, the Technical and Economic and Financial issues (external ambient). It should be taken into account that comparison among variables should take place permanently and recurrently. Comparatively, the Market alternative demonstrated greater effectivity in the priority decisions of knowledge for performance in Value Chain Managing. With regards to the Market and Politics variables, special attention must be given to VCM external variables. Allied to this, a space opens up to define the new managing strategies, while seeking to make the decision spectrum more intelligent. For decision choosing, the neuro-fuzzy model is a more efficient instrument to compare options. From the association of intervening objective and subjective variables in the decision choosing process, through a hierarchic neural network using a fuzzy inference process to convert information, it is possible to generate a numeric value denominated Effective Rate of Knowledge Priority on the innovation value chain performance. The greater the ROE, the more effective the chosen alternative for decision making for the situation hereby presented.

IV. CONCLUSIONS AND IMPLICATIONS

This work intends to contribute to the planning guidelines in the field of Value Chain Management (VCM). Thus, it develops a multi-model proposal to assess the impact of knowledge on the performance of high complexity environments. This research treated Brazil’s high-tech industries as the empirical targets. The study strived to fill a gap in the existing literature on innovation planning from the perspective of knowledge on the Value Chain Management performance. Thus, a set of psychometric scaling methods, multicriteria analysis and artificial intelligence was conceived, within a context of uncertainty and subjectivity. This procedure enables to reduce the subjectivity in the results achieved. The compelling presupposition assumed is acknowledging the importance of subjectivity in the decision-makers’ judgment; their values, their goals, their biases, their culture, their intuition, as well as the influence of subjective factors on the perception and understanding of the variables involved.

Here, the modeling approach presented gains emphasis, such diversity of methods when combined are valuable tools with great potential and significant added value, contributing to the robustness of the modeling. The feasibility of the neuro-fuzzy technology, especially in the interaction of qualitative and quantitative variables used in the modeling process, is instrumental for the optimum efficiency rate of priority in decision and performance of the Value Chain in high-tech industries. Because it is a procedure in which the attributes have subjectivity characteristics, with the intervention of specialists, the neuro-fuzzy intelligence was crucial and significant to classify the qualitative and quantitative variables converged to a single parameter, the optimal efficiency rate of technological innovation performance. This facilitates decision making within a context of uncertainty. This proposal is an additional tool available to managers, which helps to greatly reduce the uncertainty of technological innovation decisions. There are of course several issues to be further explored in other such studies, and is hoped that it contributed to a plausible modeling discussion, with much still to be explored. In light of Knowledge Management and its techniques here listed, it was possible to develop a modeling and contribute to the allocation guidelines of resources, to build the knowledge in the field of Value Chain Management. Trough this modeling a more pragmatic and efficient guidance is sought, assisting the guidelines for long-term Value Chain Managing, hence assuring this segment's competitiveness. Extensive and systematic procedures should be pursued that are capable of uniting the most diverse dimensions of Value Chain Management, surpassing the non-scientific practice often pervading some of the works. This proposal focuses on highlighting unexplored questions in this complex design. However, it evidently does not intend to be a "forced" methodology, but intends to render some contribution, even through independent course of actions.

Of the findings of the state of the art and state of practice, it is reasonable to state that this research is vulnerable to criticism. This study includes several limitations as specified below, which also helps to identify potential areas for future studies. Firstly, the study is based on the state of the art to establish the structure and contents of the model. With this spectrum, any attempt to consolidate a reconstruction and a consistent interpretation requires, first of all, analyzing the appropriate literature of events, produced by facts acquired through reliable research, i.e., extracted under conditions to obtain results that are closer to reality. And the first question about the construction or reconstruction of a model is with regards the selection, made from a profusion of events and facts that can be considered.

In the research, cross-sectional data used in this study may not be appropriate to establish fundamental relationships between variables, but as referenced by Kenny (1979), the relationships that use cross sections are satisfactory and popularly accepted in relationship tests. Furthermore, a survey was developed for Brazilian industries in a static context, which may represent a limiting factor. Therefore, it is recommended to reproduce and replicate the model in companies from other countries in order to confirm the results. It is also recommended that the knowledge dimensions should be extracted from the state of the art, but strongly confirmed by the state of practice, by the judgment of other experts (from other countries), taking into account that values, beliefs, cultures and experiences are determinants in the assessment, which can overturn the effects on the results. It is also underscored that the methodologies and technical basis of this modeling should undergo evaluation by a multidisciplinary team of specialists permanently and periodically, hence proposing possible additions or adjustments to these methodologies. And also replace some of the technical implementations used herein by others, in order to provide a similar role to verify the robustness of the model.

Of the research findings, the high-tech industries undertake the ever-fast changes, intense competition and a highly uncertain and risky environment. The effect produced by technology on the development of new products is equally intensive. Knowledge is crucial for Value Chain performance. This logic will be maintained, however only through opening spaces for the various strata: partners, suppliers and customers. Nevertheless, the capacity to innovate high-tech industries will have to be anchored in efficient planning policies. One can argue that Brazil's high-tech industry still has a long way to go and also has tremendous growth potential. Hopefully Brazil can become a technological and competitive nation. This paper is aimed at an important area for Brazil where there is a new commitment to Value Chain Management as a way of funding logistics. To be successful, Value Chain Management must be introduced with an appropriate organizational structure and within an appropriate environment. The Brazil is still in a disadvantageous position when compared to other international experiences: it lacks material, technological and human resources, rendering impossible the feasibility of projects of such greatness. Knowledge is insufficient. In this scenario, our modeling contribution is highlighted, because it provides with support for the critical priorities for the implementation of this project and is directed to building up of the intellectual capital as a key element for the development and management of the Value Chain Management. We are looking forward here to a more practical and efficient orientation supporting its long-term goals and assuring the national competitiveness concerning the category of priorities.

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