Modelling To Assess The Knowledge Impact On The Sustainable Supply Chain Performance Based On Knowledge Management

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ABSTRACT

This work intends to contribute to the planning guidelines in the field of sustainable supply chain management. Thus, it develops a modelling proposal to assess the knowledge impact on the sustainable supply chain performance based on knowledge, that considers a sequence of systematic procedures in the following phases: Phase 1: Modeling the needs of information in sustainable supply chain management; and Phase 2: Determination of the critical knowledge in sustainable supply chain management; and Phase 3: Modelling to assess the knowledge impact on the sustainable supply chain performance based on knowledge . 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 Networking (ANN) and Neurofuzzy Technology. The results produced are satisfactory, validating the proposed procedure for sustainable supply chain management.

Keywords: Modelling; Assess; Knowledge Impact; Sustainable; Supply Chain; Performance; Knowledge

I. INTRODUCTION

The characteristics of the sustainable supply chain differ a great deal [1], 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 Sustainable supply 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 ([2]; [3]; [4]).

One of the aspects that deserves to be highlighted is the occurrence of errors in the management of the Sustainable supply chain ([5]; [6]), which often results in a non-fulfillment of the established goals. It is imposed thus that the efficiency in the planning of the sustainable supply chain propitiates more efficient decisions ([7]; [8]; [9]), 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 sustainable supply chain. In this spectrum, the perspective of the efficiency of the Sustainable supply chain Management should be standardized in methods and techniques which permit a correct planning and management upon the decisions to be made.

This work intends to contribute to the planning guidelines in the field of sustainable supply chain management. Thus, it develops a modelling proposal to assess the knowledge impact on the sustainable supply chain performance based on knowledge, that considers a sequence of systematic procedures in the following phases: Phase 1: Modeling the needs of information in sustainable supply chain management; and Phase 2: Determination of the critical knowledge in sustainable supply chain management; and Stage 3: Modelling to assess the knowledge impact on the sustainable supply chain performance based on knowledge. Within this context, this paper is structured according to the following sections: methodology and conclusion.

II. METHODOLOGY

The current proposal to build up a methodological support applied to the sustainable supply chain 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 sustainable supply chain 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 sustainable supply chain management 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

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 [10]: (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 Thurstone in 1927 has been adopted. This model starts form mental behavior to explain the preference of a judge (individual) concerning a set of stimuli $\{O_1, O_2, \ldots, O_n\}$ [11]. 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 $[\pi ij]$ 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 [12], the CSF in sustainable supply chain management 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 sustainable supply chain management. In view of past experiences in the international and Brazilian scope, the high-level of Political and Market Factors preferences is justified. Undoubtedly, political instability brought forth discontinuity of great and sound projects. Oftentimes, political instability has created immeasurable systematic crisis, thus planting public policies, investments, projects, programs and State guidelines in second place.

With this scenario, having defined the political factor and its components, it is possible to understand the information that is included in the macro guidelines defined by policies and the strategic decisions, among others. To sum it up, by developing this factor, it is possible to understand the information referring to: (i) the guidelines for strategic planning of infra-structure development, backing up the investment policies; (ii) the strategic objectives to be reached by PP; (iii) the national politics of financing, within the context of other options for infra-structure financing: the institutional organization (iv) commitments of the different levels of government with the objectives, guidelines and instruments of the risks for the sustainable supply chain policy;(v) assurances of effective cost and risk advantages; (vi) maintenance of government guidelines and space for public policies; (vii) the process of communication and accountability (viii)matters of transition and working rights in sectors predominantly operated by public servants; (ix) political stability guaranties of contracts; (xii) adequate management of social and environmental impacts. Regarding the Market factor, there is a need to perceive the need for monitoring; (i) offer and demand; (ii) consumer needs; (iii) Competition; (iv) better practices and technological innovation; (v) negotiation with individuals, alliances and partners; (vi) economic details and new market opportunities; (vii) environment risk analysis; (viii) new information technology, among others.

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 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 ™. 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 sustainable supply chain management is determined in the sequence.

Aiming to know which area of the sustainable supply chain management the decision makers must develop a "strong management", the prioritization of information needs takes place. The results shown by the Methods Compromising Programming, Electre III and Promethee II have pointed out the Mercadology Area as the most relevant one to guarantee the CSF. The gathering, analysis and processing of information must be to strongly reinforce the set of activities that comprise his area, specially in what concerns the information about actions on: (a) to monitor the political, economical and social environment, environment risks that impact directly or not the organizations; (b) the best choice decision as for the contractual negotiation, specially the rights and duties between partners; (c) the best choice of partners; (d) the best build-up and management of the project; (e) the best definition of the competition policy; (f) the best definition of service levels: availability; punctuality; reliability; flexibility; managing the defect recuperation system; (g) the best definition of the costs structure; (h) the best definition policies of managing holdings; (i) the best choice of quality and productivity for policies on the sustainable supply chain; (j) competitive strategy; (k) analyze strategic planning on defense against competition; (l) monitoring and control of the environment; (m) the best choice criteria, organization, proceeding and monitoring of projects; (n) monitor risks of the project; (o) attend to demands; (p) define the best investment policy; (q) search for better environment innovation practices and new managing methods and models (demand and offer); (r) define better capital and finance structure; (s) follow-up of supply markets of input; (t) define better partnerships and alliances; (u) define planning policies and control social and environmental impacts and their mitigation; (v) the best financial engineering management; define the goals to be met; etc. In order to do so, the data gathered from the specialists were used.

Phase 2: Modelling to Assess the Knowledge Impact on the Sustainable Supply Chain Performance Based on Knowledge

This phase has been subdivided as follows:

Stage 1 - Identification and Acquisition of Knowledge; Stage 2 - Knowledge evaluation using the method of Categorical Judgments of Thurstone (1927) and artificial neural network (ANN); and Stage 3 Modelling to assess the knowledge impact on the sustainable supply chain performance based on knowledge. 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 sustainable supply chain management. Following this, they will be reviewed and organized and validated by sustainable supply chain management 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 [13] [14] [15].

Acquiring the knowledge (from specialists) implies, according to [13], [14]; [15], 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 [16] is dealt with, which is the information to be understood by and useful for the decision making in sustainable supply chain management. 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 [17]. 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 sustainable supply chain management projects are identified. In other words, which knowledge and theory are required to be known in order to ensure the success of projects on sustainable supply 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 framework and concepts.

Stage 2 - Knowledge Evaluation Using Method of Categorical Judgments of Thurstone (1927) and Artificial Neural Network (ANN)

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 sustainable supply chain management, 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. 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) and Environment (EN).

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 that there is no great predominance of another type of knowledge, and this should be considered in sustainable supply chain management. However, there are those with more relevancies in the decision maker's preference. Therefore, the best decision is sought, considering the background of each Sustainable 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 sustainable supply 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 sustainable supply chain management; (2) quality and productivity for policies on the Sustainable supply 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 Sustainable supply 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 sustainable supply chain management, as well as for the constitution of other elements of the intellectual capital in sustainable supply chain management.

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. The reached results proved satisfactory, emphasizing the subjective importance of the scale methods to treat questions that involve high degree of subjectivity and complexity. With regards to the topologies of the used networks, the results obtained some configurations of the ANN and compared with the CJT, it was observed that ANN 1, is the one that best approached the classification obtained for the CJT. 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. The results can be observed in Figure 1 that follows.

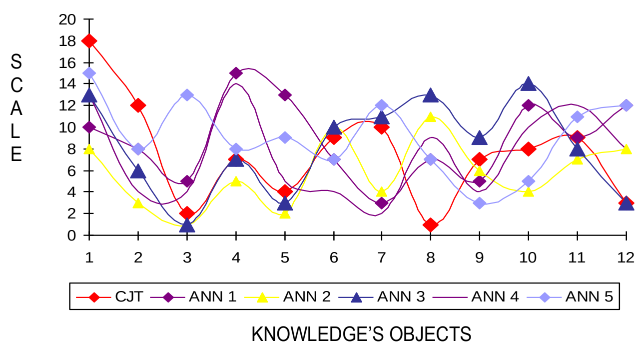

Fig. 1: Priority of Knowledge's Objects - ANN and CJT

The prioritized objects for the tool proposals were for sustainable supply chain management 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.

Stage 3: Modelling to Assess the Knowledge Impact on the Sustainable Supply Chain Performance Based on Knowledge

This phase focuses on determining the optimal efficiency rate (OERP) to assess the knowledge impact on the sustainable supply chain performance based on knowledge using neurofuzzy modeling. It is a process whose attributes usually possess high subjectivity characteristics, in which the experience of the decision maker is very significant. Thus within this spectrum there is the need for a tool that allows adding quantitative and qualitative variables that converge towards a single evaluation parameter [18]; [19]. This model combines the Neural Networks and Logic Fuzzy technology (neurofuzzy technology). Here this model supports the planning of the sustainable supply chain, as it allows to evaluate the desirable rate toward the acceptable performance of the sustainable supply chain. The model shown here uses the model of [18]. Based on the neurofuzzy technology, the qualitative input data are grouped to determine the comparison parameters between the alternatives. The technique is structured by combining all attributes (qualitative and quantitative variables) in inference blocks (IB) that use fuzzy-based rules and linguistic expressions, so that the preference for each alternative priority decision of the optimal rate of technological innovation performance determinants, in terms of benefits to the company, can be expressed by a range varying from 0 to 10. The model consists of qualitative and quantitative variables, based on information from the experts. The Neurofuzzy model is described below.

Determination of Input Variables (IV): This section focuses on determining the qualitative and quantitative input variables (IV).

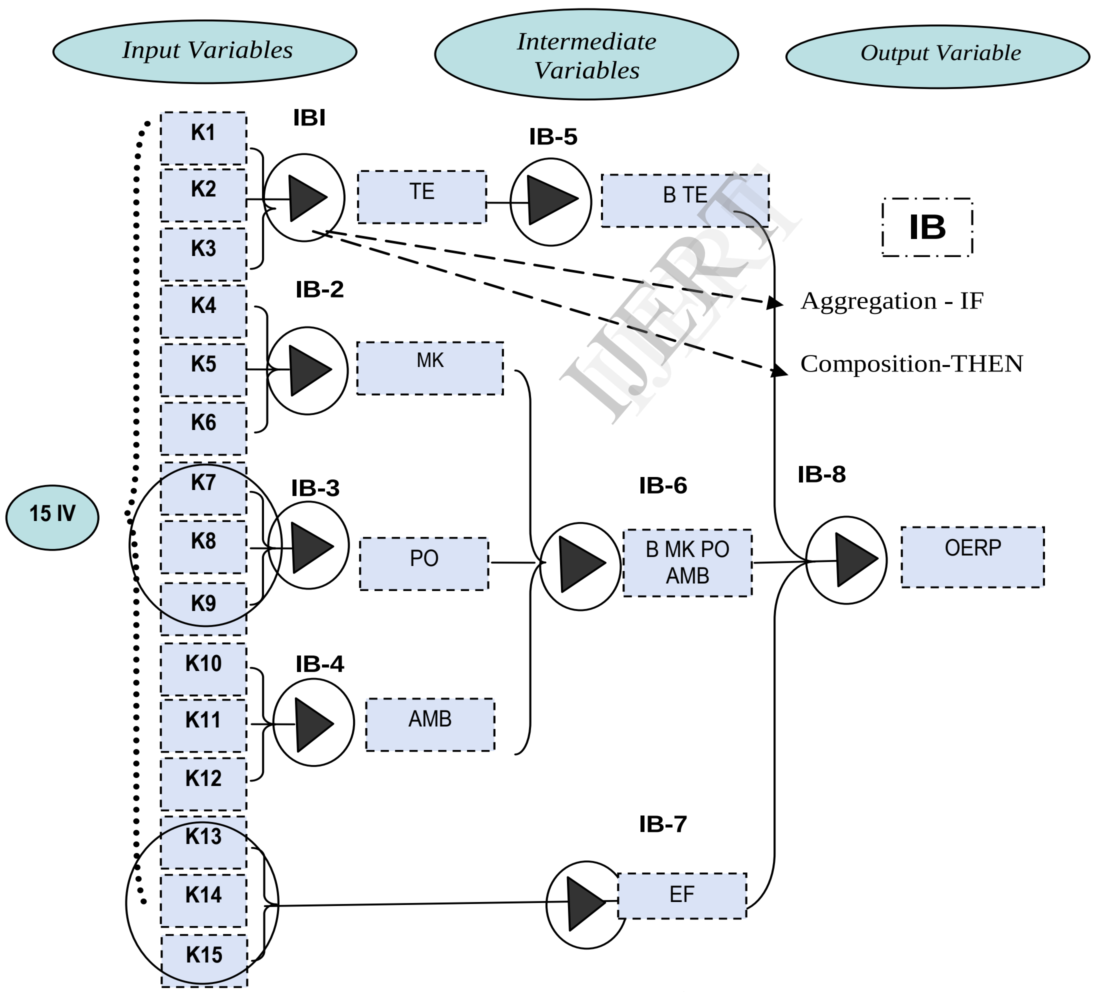

Fig. 2: Neurofuzzy Model

These variables were extracted (15 variables) from the independent variables (knowledge). The linguistic terms assigned to each IV are: High, Medium and Low. Accordingly, Stage 2 shows the IVs in the model, which are transformed into linguistic variables with their respective Degrees of Conviction or Certainty (DoC), with the assistance of twenty judges opining in the process. The degrees attributed by the judges are converted into linguistic expressions with their respective DoCs, based on *fuzzy* sets and IT rules (aggregation rules), next (composition rules).

Determination of Intermediate Variables and Linguistic Terms: The qualitative input variables go through the inference fuzzy process, resulting in linguistic terms of intermediate variables (IVar). Thus, the linguistic terms assigned to IVar are: Low, Medium and High. The intermediate variables were obtained from: Marketing Political Environnment Technical Performance; Economic and Finance Performance. The architecture proposed is composed of eight expert fuzzy system configurations, four qualitative input variables that go through the fuzzy process and through the inference block, thus producing an output variable (OV), called intermediate variable (IVar).

Then, the IVars, which join the other IVar variables form a set of new IVars, thereby configuring a sequence until the last layer in the network. In the last layer of the network the output variable (OV) of the neurofuzzy Network is defined. This OV is then subjected to a defuzzification process to achieve the final result: Optimal Efficiency Rate of Technological Innovation Capacity Performance of High-Tech Companies. In summary, the fuzzy inference occurs from the base-rules, generating the linguistic vector of the OV, obtained through the aggregation and composition steps. For example, when the experts' opinion was requested on the optimal efficiency rate for the technological innovation capacity performance of company A, the response was 8.0. Then the fuzzification (simulation) process was carried out, assigning LOW, MEDIUM and HIGH linguistic terms to the assessment degrees at a 1 to 10 scale. Degree 8, considered LOW by 0% of the experts, MEDIUM by 50% and HIGH by 60% of the experts. In summary, the expert's response enabled to determine the degree of certainty of the linguistic terms of each of the input variables using the fuzzy sets. The generic fuzzy sets were defined for all qualitative IVars, which always exhibit three levels of linguistic terms: a lower, a medium and a higher one. After converting all IVars into its corresponding linguistic variables with their respective DoC, the fuzzy inference blocks (IB), composed of IF-THEN rules, are operated based on the MAX-MIN operators, obtaining a linguistic value for each intermediate variable and output variable of the model, with the linguistic terms previously defined by the judges. With the input variables (features extracted from product development projects), the rules are generated. Every rule has an individual weighting factor, called Certainty Factor (CF), between 0 and 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 OV, obtained through the aggregation and composition steps.

Determination of Output Variable – Optimal Efficiency Rate of knowledge Performance

The output variable (OV) of the neurofuzzy model proposed was called Optimal Efficiency Rate of Knowledge Performance. The fuzzification process determines the pertinence functions for each input variable. If the input data values are accurate, results from measurements or observations, it is necessary to structure the fuzzy sets for the input variables, which is the fuzzification process. If the input variables are obtained in linguistic values, the fuzzification process is not necessary. A fuzzy set A in a universe X, is a set of ordered pairs represented by Equation 1.

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

Where *(x)* is the pertinence function (or degree of pertinence) of x in *A* and is defined as the mapping of *X* in the closed interval [0.1], according to Equation 2 [20].

$$\mu_A(x):X \rightarrow [0.1] \quad (2)$$

Fuzzy Inference: The fuzzy inference rule-base consists of IF-THEN rules, which are responsible for aggregating the input variables and generating the output variables in linguistic terms, with their respective pertinence functions. According to [19], a weighting factor is assigned to each rule that reflects their importance in the rule-base. This coefficient is called Certainty Factor (CF), and can vary in range [0,1] and is multiplied by the result of the aggregation (IT part of inference). The fuzzy inference is structured by two components: (i) aggregation, i.e., computing the IF rules part; and (ii) composition, the THEN part of the rules. The Degree of Certainty (DoC) that determines the vectors resulting from the linguistic processes of aggregation and composition are defined with Equation 3.

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

Defuzzification: For the applications involving qualitative variables, as is the case in question, a numerical value is required as a result of the system, called defuzzification. Thus, after the fuzzy inference, fuzzification is necessary, i.e., transform linguistic values into numerical values, from their pertinence functions (Von Altrock, 1997). The IT Maximum Center method was popularized to determine an accurate value for the linguistic vector of OV. Based on this method, the degree of certainty of linguistic terms is defined as "weights" associated with each of these values. The exact value of commitment (VC) is determined by considering the weights with respect to the typical values (maximum values of the pertinence functions), according to Equation 4 presented below [18]; [19].

n

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

Where i DoC represents the degrees of certainty of the linguistic terms of the final output variable and i X indicates the end of the typical values for the linguistic terms, which correspond to the maxima of fuzzy sets that define the final output variable. By way of demonstration, using assigned IT (average) hypothetical (Company A) enters-IT into the calculation expression of TPCITj with GdCi of the following linguistic vector of the output variable, also hypothetical: LOW=0.35, MIDDLE=0.50, HIGH=0.15. The numerical value of OERP at a 0 to 1 scale corresponds to 0.7352, resulting from the arithmetic mean of the values resulting from the defuzzification of each of the simulated twenty judges. This value corresponds to an average value for OERP. With this result (optimal efficiency rate: 0.8529) produced for a better combination and interaction of strategic knowledge impact performance that converged toward a single parameter, it is feasible to assert that this combination of technological innovation activities of the firm at this time, can at least ensure the performance desired by the firm at that time. It is plausible that the company maintains at least this value (0.7352), which ensures the desired performance.. The environmental contingencies are crucial and essential to adapt the strategies. The modeling approach presented here enables this sophistication refinement for every contingency presented.

III. CONCLUSION

This work intends to contribute to the planning guidelines in the field of sustainable supply chain management. Thus, it develops a modelling proposal to assess the knowledge impact on the sustainable supply chain performance based on knowledge. The study strived to fill a gap in the existing literature. The present work about sustainable supply chain management comes to an end, and hopes to have contributed for methodological discussions that need further investigation. Moreover, there is a need to understand sustainable supply chain management regarding social demands that are created within their appropriate social, economic and political context. And evidently many questions remain to be untangled in future studies of this type, specifically of planning in highly complex spectrum of, as the sustainable supply chain management. It is 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.

The proposed methodology developed in this work differentiates from other decision support methods, by extracting the tacit knowledge and converting it into explicit knowledge of managers in sustainable supply chain management. In light of knowledge management and its techniques here listed, it was possible to develop a methodology proposal and contribute to the allocation guidelines of resources, to build the intellectual capital in the field of sustainable supply chain management. Therefore, it is essential to guide such strategic elements of knowledge. By basing on the Knowledge Management and its techniques, we have developed the proposal of a methodology that is focused on contributing to patterns of resource allocation to build-up intellectual capital on sustainable supply chain management. This methodological support does not intend to be complete, but it is our intent to make it a generator of strategical elements for the development of sustainable supply chain projects. It is here where the knowledge is important, being a key instrument to develop projects in such a complex issue as it is the case of sustainable supply chain.

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