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Model for Technological Innovation Integration and New Product Development in High Tech Environments

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ABSTRACT: The products introduced to the market that make use of the technology developed require ensuring the integration between the technologies and the products developed, minimizing risks and maximizing results. This article aims to contribute to a new planning policy in the development of innovative products. To do so, it presents a new modeling proposal to integrate technological innovation and new product development (NPD) in high tech environments, carried out according to the following stages: Phase 1: Modeling of the information needs in PDP; Phase 2: Determining of technology integration dimensions to the product; Phase 3: Evaluation of performance of technology integration dimensions to the product. To demonstrate the feasibility and plausibility of the modeling, a study case was conducted in a high tech company in Brazil. The investigation was helped by the intervention of specialists with technical and scientific knowledge about the research object. In order to reduce the subjectivity in the obtained results, the methods of Categorical Judgment Law (CJL) of Thurstone from 1927, Artificial Neural Networks (ANN), the multicriteria Electre III methods, Compromise Programinng and Promethee II; Multivaried Analysis and the neurofuzzy technology were used. Few studies have investigated the Product-Integration Technology. It is hoped that this study will stimulate a broad debate on the issue and it is acknowledged that more studies are needed to build more robust results in the near future. The results were satisfactory, validating the present proposal.

KEYWORDS: Modeling proposal, Planning, Integration, Technological innovation, New product development, High tech environments.

1 INTRODUCTION

Recently, relevant changes have made organizational boundaries more fluid and dynamic in response to the rapid pace of knowledge diffusion [1]; [2]; [3], and innovation and international competition [4]. This helps to reconsider how to succeed with innovation [5]; [6]. Thus, innovative companies make use of their capabilities to appropriate the economic value generated from their knowledge and innovations [2]; [3]. Therefore, the supply of innovative products is presented as a quality standard in the race for pressing demands.

In this spectrum, the innovation process management becomes one of the greatest challenges. The literature refers to the product development process (PDP) and the technology development process (TDP) as the most relevant to the development of innovative products [7]. Thus, it is feasible that there is a concurrent and harmonic planning between these processes. For that, it is logical that the integration between these processes is successful, since the success of the innovation depends on the integration of them [7]. Because technology and product have different cycles, the development projects face problems related to the incorporation or commercialization of new technologies. The results are time and efforts underestimated to develop and use new technologies, besides developing Technologies without having a pre-determined product, with different maturity degrees, which implies in high costs, quality waste and inadequate deadlines.

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2 Modeling: Steps and Implementation

This article aims to contribute to a new planning policy in the development of innovative products. To do so, it presents a new modeling proposal to integrate technological innovation and new product development in high tech environments. The research was developed over the literature specialized and applied to a technologic base company in Brazil, in the field of nanotechnology, to confirm the modeling proposal and the theoretical excerpts. The research also had the intervention from specialists with knowledge about the investigated object, to confirm the modeling (structure and content).

At a second moment, the data (partners and owners) from the researched company were gathered to demonstrate the modeling. Next, the details from the modeling phases and stages were detailed. *Phase 1:* Modeling of the information needs in PDP; *Phase 2:* Determining of technology integration dimensions to the product*; Phase 3:* Evaluation of performance of technology integration dimensions to the product. Next, those procedures are detailed:

Phase1: Modeling of the Information Needs (technological base company)

This phase is structured according to the following stages and sub-stages: *stage 1* - definition of the characteristics of the products; *stage 2*: determination of the strategies of technological synchronization used by companies to the development of products; *stage 3* – Definition of the strategies of the innovation development and *stage 4*: Priorization of the information needs.

Stage 1: definition of the characteristics of the product: here are presented the product main characteristics.

Stage 2: determination of the strategies of the technological synchronization used by companies to manage the development of products. There are two strategies listed in the consulted literature: 1) simultaneous transference; 2) sequential transference.

Stage 3: Definition of the strategies of the innovation development. Two strategies were identified in the literature [13] consulted: bottom-up and top-down.

Stage 4: Priorization the needs of information the needs of information: This phase is structured in three stages: Sub-Stages 1) determination of the Critical Success Factors (CSF); 2) determination of the information areas (IAs); and 3) prioritization of the information needs starting from the crossing of CSF and the Areas of Information.

Sub-Stage 4.1: 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 [8] has been adopted. This model starts form mental behavior to explain the preference of a judge (individual) concerning a set of stimuli {O1, O2,…, On}. 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 [pij] 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.

Sub-Stage 4.2: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 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.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 [8] has been adopted. As a result, a hierarchical structure of IAs is obtained.

Sub-stage 4.2.1: Determine the activities of the PDP In this sub-stage the main activities realized during the PDP are identified. The following activities performed according to the literature were identified [6]; [9], [10]; [11]: development of the concept of product, elaboration of the product syllabus, preparation of the production, launching and after-launching of the product. Determine strategies and product *portfolio*; elaboration and detailing of the project syllabus; determine technical and marketing merits of the project; realization of preliminary research to identify and analyze the market, technology and business characteristics; Identify and evaluate the consumer's claim by market sector (market research); Define the architecture and requirements of the product; carry out product competitive benchmarking; define functionalities of the Math product; generate assessment criteria of the concept of the product and carry out tests of concept among others.

Sub-stage 4.2.2: Determine the TDP activities

In this sub-stage the main activities of TDP based on [6]; [9]; [12]; [10]; [11] are identified: (i) company strategic planning; (ii) determination of the technologic strategy; (iii) technology; (iv) consumer; (v) generation of ideas (vi) elaboration of project syllabus; (vii) future plans mapping; (viii) patent research; (vix) Identification of opportunities; (x) identification of the possibility of the idea in determined conditions through preliminary experiments; (xi) identification of the necessary resources and solutions for the identified failures; (xii) projection of platforms of products; (xiii) creation of QFD for technology (technological needs); among others. Soon after this procedure, the critical activities for integration are determined.

Sub-stage 4.2.3: Determination of the critical activities for integration

In this stage, the critical activities for integration of the technology to the product are defined. Integration must be understood as the set of activities or compatible practice between TDP and PDP [13], which aim at improving the application of knowledge to the products. Next, the IA global performances are evaluated according to the CSF.

Sub-Stage 4.3: 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 [8] 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 ™.

Phase 2: Determination of the dimensions of the integration of the technology to the product

In this stage the dimensions of the integration of the technology to the product are defined. [13] presents the following dimensions of the integration of the technology to the product: aspects, activities and time horizon. [14] considers other three dimnesions of the integration: Strategic and Operational synchronization, 2) Syllabus Transference, and 3) Transference Managemnet. Finally, [15] point out three basic elements for integration: 1) Synchronization; 2) Technology Equalization; 3) Technological Transference Management. [16] adopts the knowledge as the main dimension for the integration of the technology to the product. For this author, there will be integration IF the knowledge generated by the area of R&D is applied to a new product. In this work, the knowledge is the dimension to be considered for the integration. This dimension is detailed ahead. *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 PDP and TDP. Following this, they will be reviewed and organized and validated by NPD and TDP 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 [17]; [18].

Acquiring the knowledge (from specialists) implies, according to [19], [20], 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 [21] is dealt with, which is the information to be understood by and useful for the decision making in technological innovation integration and new product development. 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. 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 new products development projects are identified. In other words, which knowledge and theory are required to be known in order to ensure the success of projects in the NPD 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.

Phase 3: Assessment of the performance of the integration of technology process to the product

In this phase the assessment of the performance of the integration of technology process to the product is done. This procedure is realized based on the neurofuzzy technology. The variables (knowledge) identified in the previous phase are input data for the neurofuzzy modeling (in this phase). Thus, this phase focuses on determining the optimal efficiency rate (OERP) of the high-tech industries'product development and technology integration 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 [22]; [23]. This model combines the Neural Networks and Logic Fuzzy technology (neurofuzzy technology). Here this model supports the product development and technology integration using Neurofuzzy modeling of high-tech industries, as it allows to evaluate the desirable rate toward the acceptable performance of high-tech companies.

The model shown here uses the model of [22]. 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 efficiency rate of the high-tech industries' product development and technology integration, 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.

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 on the network. This IV, then joins another IV, forming a set of new IVs, hence configurating a sequence on the last network. In the last layer, also composed of IV, it produces the output variable (OV) of the final NNA. The NNA architecture should be applied according to the number of specialists. These steps are detailed below.

Determination of Input Variables (IV): This section focuses on determining the qualitative and quantitative input variables (IV). These variables were extracted (15 variables) from the phase 2. (ranking of dimensions of knowledge). The linguistic terms assigned to each IV are: High, Medium and Low. Accordingly, phase 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).

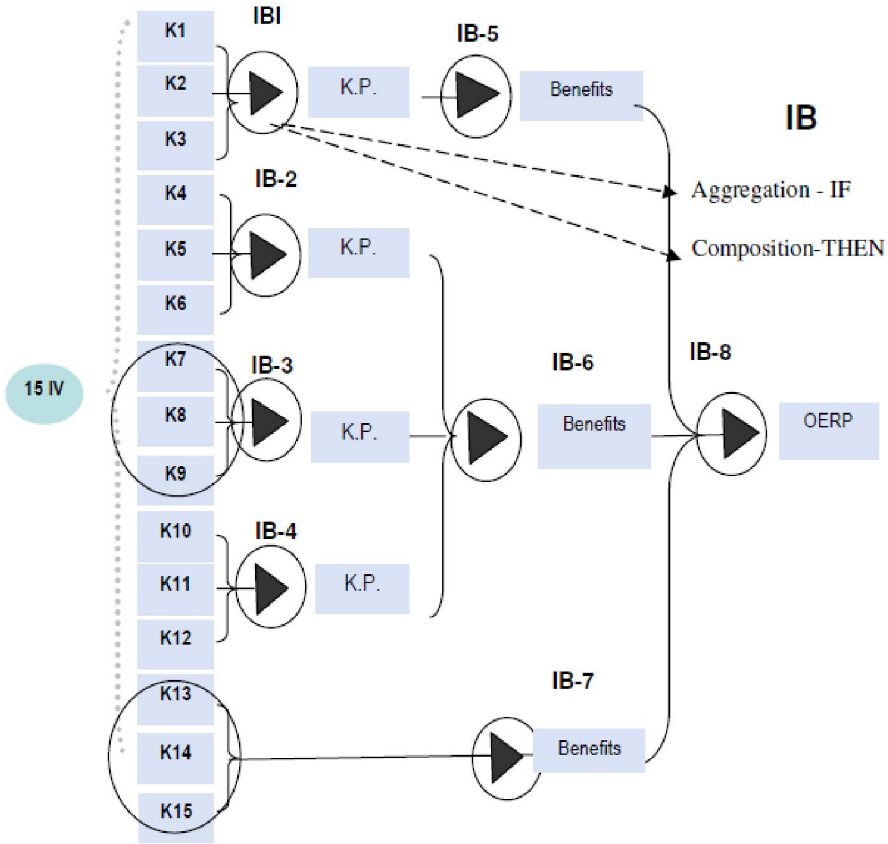

Fig. 1. Neurofuzzy Model

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: knowledge 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 (OERP) of product development and technology integration performance.of high-tech industries. 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 product development and technology integration performance of company, 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 60% and HIGH by 40% 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 product development and technology integration! Performance

The output variable (OV) of the neurofuzzy model proposed was called Optimal Efficiency Rate of *product development and technology integration* in high-tech company. 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 (Pedrycz and Gomide, 1998).

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

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 [23], 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 [23]. 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 [22]; [23].

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

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) 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=0.45, HIGH=0.20. The numerical value of OERP at a 0 to 1 scale corresponds to 0.8892, 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: 0.08892) produced for a better combination and interaction of knowledge (IV) of product development and technology integration that converged toward a single parameter, it is feasible to assert that this combination of knowledge (IV) 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 (0.8892), which ensures the desired performance. It is also plausible to state that, to some degree, there is efficiency in the management of those planning technological innovation and product development in this category of industries high tech.

3 Application and Underlying Analyses

This section presents the verification procedures for the model. To demonstrate the feasibility and plausibility of the model, an implementation was based company in Brazil. Next, The detail of the steps.

Company structure and product characterization: The modeling was applied to a company of technological base in Brazil, in the nanotechnology Field. The data were gathered by consulting the partner-owners of the investigated company, through a structured questionnaire. In this investigation, it was possible to know details of the company's PDP and TDP, in a way of verifying the practices conducted in the process of integration of the technology to the product. The research was based on a product (from the company) well succeeded in the national market, according to its innovation degree (for the market), having the OCDE (2005) reference as a basis. It is believed that the product passed through the 2 fundamental stages identified in the theoretic excerpts: the PDP and TDP. The organizational structure of the company is comprised of the following areas: R&D, commercial, administrative/financial, and by and administrative counseling. The company has been on the market for 8 years. The main object of the company is the development of products for application of tiles on different product surfaces, with multiple purposes, such as anti-germs, barriers against corrosion, among others that are possible through this kind of technology. Based on the proposal previously presented (section 2), the following CSF from the company were identified: Political/Legal; Economical and Financial; Market and Technical. The main IAs identified was: R&D; Commercial and Financial.

The process of development of the Technology: The technology of the studied product was developed in an approximately 2 years time. During its whole development, three partner owners from the company who are responsible for the P&D information, Commercial and Financial areas participated directly. The main PDT activities were as it follows: (i) carry out research through the literature, (ii) select and develop a superior concept of technology, define functionalities of the new technology (iii) optimize the technology from its critical parameters.

The product innovative technology in question was developed in a previous project, developed by the partner-owners, during a post-graduation course. Therefore, the activities were developed in labs of academic research, which enabled to obtain a structure of human resources involving teachers and physical resources comprising labs with the necessary support for the generation of the development of the technology. In this sense, the origin of this solution, which later would result in a business, had as a fundamental element the basic research. The owners established the company, therefore, with the technology in its early stage of development, a result from the post-graduation research. The first step was the realization of the research in the literature and in events to identify the trends in the market and in materials. Later, the group of research initiated the elaboration of the material, identifying the behavioral characteristics. Finally, tests in outsourced labs were conducted to get the certification of the technology developed. With that market opportunity, a patent was requested to secure the ownership [24].

The process of development of the product. Soon after the participation of the company in a fair of nanotechnology, the PDP was started. It was the moment in which there was the first commercial contact with a determined company that showed interest in the coverage of pieces of their products with the developed technology. The main PDP activities identified are as it follows: realization of the concept test; realization of the test and validation of the proposal of new product; realization of strength tests according to parameters; start the pilot production; launching of the product and realization of the effective production. Soon after the contact, the client company identified the pieces that were important to be covered in a way that it would aggregate value to the product. So, the pieces were submitted to applications and experiments with the new technology and the specific product to cover such types of parts was developed. To identify whether the technology met the needs of the client, such as appearance and bacterial property, tests in outsourced labs were conducted. After the results of test conclusions were released, the optimization of the application was started. In this stage, it was defined the structure of production for the application of the technology and improvement in the composition of materials [24]. It was produced a pilot lot so the client company could launch the product in an event within its sector. From the satisfactory results of product acceptance in the market, the large-scale production was started, which remains until the current moment of this study. The time between the first commercial contact and the delivery of the product with the applied technology was approximately one year, which half of this period was oriented to experiments and tests of application of the technology on the selected pieces.

The strategy of the development of the innovation adopted by the company for the development of the technology was bottom-up, or technology push, for on its beginning the development team, composed of three partner-owners, did not own a clear plan or idea to integrate this technology to the studied product. They did not even possess a more detailed vision about the possible consumer market or the focus of these markets. It was all about an academic research work that had only an informal perceptive identification, as they themselves called it, of the market opportunities. Initially the company did not have as the main target the studied product. In the beginning the idea was to develop a technology to cover the metal characterizing this strategy at first as top-down and later as a redirecting of its application, identifying market trends and the needs of applications of the technology in other products [24].

The strategy of technological synchronization adopted was the sequential transference of technology. At first, the technology was developed, then, the product. This was due to the fact that the technology was developed first to the market during the research in the post-graduation course of the partner-owners. Moreover, the company participated in the event that led to the studied product in this work with the technology ready to be applied to the product. Yet not validated, but already in advanced stage of development. After some experiments were conducted with the selected pieces, it was verified the need of some adaptations in the technology [24]. At this moment, the existing synchronization between the processes becomes the simultaneous transference of technology, for during the adaptation of some chemical compositions of the technology; activities such as appearance and performance tests were also realized.

Besides, this case allowed to identify a time of 2 years, more than which the chance is smaller for the product project team and technology to share the results of the project. Thus, it is assumed that if the projects were realized with a time difference of 2 years maximum, they can be characterized as simultaneous synchronization. It is important to point out that through the identification of the strategy of synchronization the two-year time was noted as the necessary time for the company to validate and incorporate technology in a product so it can be commercialized. Once the activities of PDP and TDP and the critical activities were defined, the next step was to define the concept of technology to be adopted in this application. The concept adopted has basis in the knowledge. The literature defines technology as the knowledge applied to obtain a product (a practical result). Afterwards, iniciou-se the procedure of transference of technology (knowledge) to the product was started. On one hand, the knowledge/technologies demanded by the product (PDP). On the other hand, the knowledge offered by technology (TDP). As aforementioned, the integration of the technology to the product has basis on the proposal of [16], which has the knowledge as the main dimension of the integration of the technology to the product. The information area adopted in this application was R&D. The process of integration using the knowledge is shown as it follows.

The process of integration of the technology to the product: The concept adopted to knowledge are the theoretical bases and concepts and information of context. In this sense, the necessary knowledge to carry out the concept test was adopted; realization of test and validation of the proposal of a new product; realization of strength tests according to parameters; start of the pilot production; product launch and realization of the effective production, among others. The knowledge (technology) presented in tables 1 and 2 was preliminarily identified.

Table 1. Theoretical bases and concepts

Knowledge (Stmulis)	C1	C2	C3	C4	Total	Ranking
ENGE	-0,76471	0,430728	0,430728	0,76471	0,861456	**14º**
TI	-0,76471	-0,76471	0,430728	0,430728	-0,667964	**11º**
M.E.MQ	-1,22067	-1,22067	-1,22067	-0,43073	-4,09274	**2º**
GR	-1,22067	-1,22064	-0,13971	0,430728	-2,150292	**6º**
M.C.A.F.	-1,22067	-1,22067	-0,76471	-0,13971	-3,34576	**4º**
T.E.F.	-1,22067	-1,22067	-0,76471	0,76471	-2,44134	**5º**
CONT.	-1,22067	-1,22067	-0,13971	0,76471	-1,81634	**8º**
CUS	-1,22064	-0,13971	0,76471	1,220642	0,625002	**13º**
M.A.P.	-1,22067	-1,22067	-0,43073	1,220642	-1,651428	**9º**
T.P.	-1,22064	-0,13971	1,220642	0,13971	0,00017	**12º**
E.F.P.	-1,22067	-1,22067	-1,22067	-1,22067	-4,88268	**1º**
M.N.	-1,22067	-1,22067	-0,76471	0,76471	-2,44134	**5º**
R.D.P.	-1,22067	-1,22067	-0,43073	0,76471	-2,10736	**7º**
AD.	-1,22067	-1,22067	-1,22064	0,13971	-3,52227	**3º**
T.C.T.	-1,22067	-1,22064	-0,13971	1,220642	-1,360378	**10º**

Table 2. Contextual information

Knowledge (Stimulis)	C1	C2	C3	C4	Total	Ranking
E.F.	-1,22067	-1,22067	-1,22067	-1,22067	-4,88268	**1º**
E.T.	-1,22067	-1,22067	-1,22064	-0,13971	-3,80169	**3º**
P.T.	-1,22067	-1,22067	-1,22067	0,13971	-3,5223	**4º**
E.C.	-1,22067	-1,22067	-0,76471	0,13971	-3,06634	**5º**
G.R.	-1,22067	-1,22064	-0,43073	0,13971	-2,73233	**6º**
T.I.	-1,22064	-0,43073	0,430728	3,86499	2,644346	**12º**
E.F.	-1,22067	-1,22067	-0,76471	0,13971	-3,06634	**5º**
E.D.	-1,22067	-1,22064	-0,43073	0,76471	-2,10733	**8º**
I.E.F.	-1,22067	-0,76471	-0,13971	0,76471	-1,36038	**10º**
SU	-1,22067	-0,13971	-0,13971	1,220642	-0,27945	**11º**
S.F.	-1,22067	-1,22064	-0,43073	1,220642	-1,6514	**9º**
A.E.F	-1,22067	-1,22067	-0,76471	0,76471	-2,44134	**7º**
F.	-1,22067	-1,22067	-1,22067	-0,43073	-4,09274	**2º**

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 technological innovation, TDP and PDP, 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 (CJL) 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/technology). 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 (Tables 1 and 2).

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 (technology). 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 0,37 and equal moment 0,88. 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 networks, and parameters, got the obtained network that showed better results was presented. The network was trained for the attainment of two result groups to compare 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 more satisfactory results. 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 2 that follows.

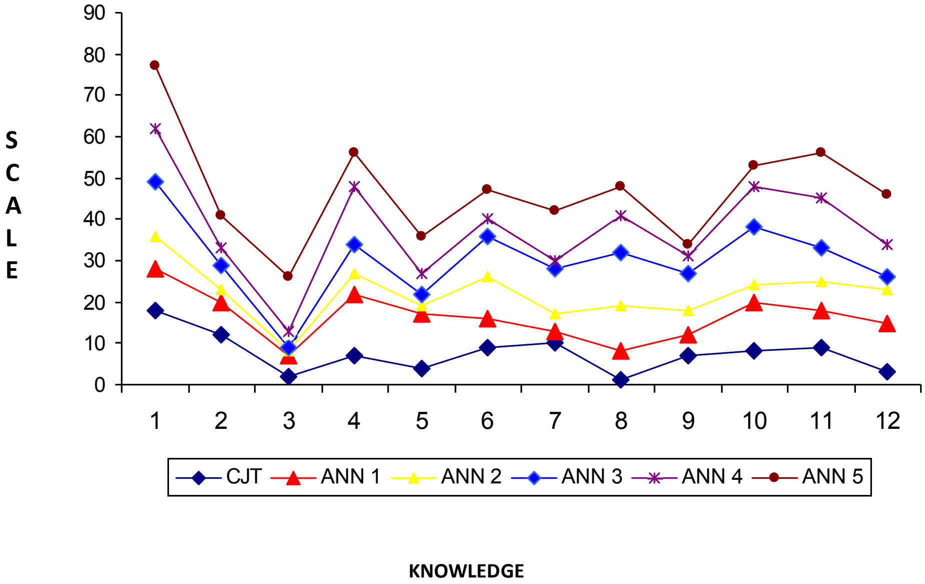

Fig. 2. Priority of Knowledge's Objects - ANN and CJT

The prioritized knowledge's objects for the tool proposals were for assessment of the performance of the integration of technology process to the product in high tech environments, Artificial Neural Networks (ANN), as well as Psychometric (CJL), 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 CJL 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 CJL. The integration of these variables in the *neurofuzzy* model results in a unique value which is the performance of the integration of the technology to the product. This enables to verify whether the procedure of integration was or not successful. The first 15 classified variables were used. The results showed a great efficiency rate of integration of the technology to the product equal to 0,89. This value corresponds to an average value for OERP. With this result (optimal efficiency rate: 0,89) produced for a better combination and interaction of knowledge dimensions (technologies) that converged toward a single parameter, it is feasible to assert that this combination of knowledge. It is also plausible to state that, to some degree, there is efficiency in the management of those NPD planning in this category of companies. To illustrate this, assuming that the study-object company demonstrate the following optimal efficiency rates (efficiency rate of integration of the technology to the product): T1 – 0.7833; T2-0.4442; T3-0.8974; T4-0.4983; AND- T5-0.4782 (Figure 3).

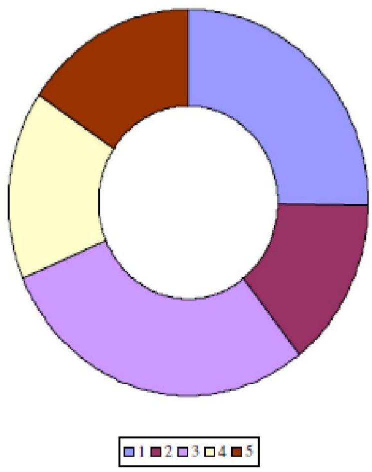

Fig. 3. Efficiency rate of integration of the technology to the product

The best performance of the integration of technology process to the product T3 (0,8974)

4 CONCLUSIONS AND IMPLICATIONS

This article aims to contribute to a new planning policy in the development of innovative products. To do so, it presents a new modeling proposal to integrate technological innovation and new product development in high tech environments. The modeling has as the central element the integration of technology to the product. The building started off from the modeling of the needs of information, with the definition of the characteristics of the product, of the strategies and the component activities of PDP and TDP, besides the priorities of information. Next, it was defined the knowledge as the dimension of the integration of the technology to the product, a proposal from [16]. Finally, the modeling to determine the performance of the process of integration of the technology to the product was developed. This procedure was conducted with the help of neurofuzzy technology. The performance of the integration was based on the knowledge (VE - input variables) of the neurofuzzy model. The performance is the result produced by the integration and convergence of the VEs to a unique value (output variable - VS), called performance rate of the integration of the technology to the product. The result enables to improve the planning policy to the development of new products, and set new strategies to the process of integration of technological innovations and the development of products.

The results obtained with the application of the proposed model show that this technology is adequate for supporting decision-making, due mainly to its low level of complexity and to its flexibility, that allows the input and output of variables. Through this method a more pragmatic and efficient guidance is sought, assisting the guidelines for long-term to integrate technological innovation and new product development in high tech environments, hence assuring this segment's competitiveness. Extensive and systematic procedures should be pursued that are capable of uniting the most diverse dimensions of planning of innovative products, 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.

By gathering the cognitive elements, it can be seen that this strategy requires a priority dynamics, which is dependent on the initial state of training, on the concrete characteristics of the projects and cognitive problems that emerge during the practice, always putting in view new contents. In the near future, we aim to demonstrate the suitability and feasibility of the proposed modeling framework, priority researches must be permanently and recurrently applied. Thus, 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 new new products development projects. 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 limitations as specified below, which also helps to identify potential areas for future studies. A study was developed for Brazilian high tech company 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 dimensions of the integration of the technology to the product 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. Nevertheless, the new products development 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.

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