Selection of a new product development model for technology-based electronic companies

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Abstract: The main purpose of the present article is to select a reference model for a new product development process, which must be the most appropriate for technology-based electronic companies. The object of the study is the local productive settling of Santa Rita do Sapucai, State of Minas Gerais, Brazil. In recent literature research, a trend in performing studies that focus on specific models applied to singular sectors in industry fields has been identified. The research approach is based on a mathematical modeling. Analytic Hierarchy Process is applied in order to identify the most suitable model to technology-based electronic companies.

Keywords: AHP, new product development, technology-based company.

1. Introduction

The market has been suffering changes which form a dynamic context for the organizations, especially in the Brazilian industry. For the TBC (technology-based companies), the competition among similar foreign products comes from countries with higher technological development levels and with lower manufacturing costs than in Brazil. This scenario demands that TBC must continuously assimilate and develop new technologies and products, searching for not only cost reduction, time for new product development and non-conformities, but also an increasing reliability, and, therefore resulting in the maintenance and enlargement of the market. In other words, these procedures just mentioned help the company itself remain competitive in the global market.

This context is more relevant to the TBC that are high-tech companies, whose competitiveness depends on the design, development and manufacturing of innovative products or processes. These companies often operate in small scales, once these innovative activities are under risks of developing technology which may not be frequently tested in the market (ASSOCIAÇÃO..., 2002). However, a great part of TBC is facing the problem of not being prepared to innovate their processes, especially when NDP (new product development) is considered. In most of these cases, the companies use ordinary models, which are common for any type of development process. Nevertheless, these models are not always adapted to their business model.

Usually, the problems found in TBC are due to the lack of a specific model or to the adaptation of one or more of previously developed models:

- The existing models do not contribute to increase TBC's product value from a customer's view;
- It is spent too much time and energy on adjusting the real process to the format imposed by a determined model, which is for some reason adopted by the company;
- Current models can create difficulties in order to recognize better solutions for the development in question ("freeze the process");
- There is a trend to make things always as the same way, where identification of improvement opportunities is not found.

Moreover, recently, it has been given a stronger attention from academic research on pointing out what is common to some models of product development rather than focusing on aspects about the differences and adjustability of models that are more recommended to a certain type of business. For that scenario being so, it is identified a trend on developing research. This trend can be found in works such as Ledwith (2000), Yang and Yu (2002), Romano (2003), Gómez, Vidal and Alcamí (2004), Thier (2005), Zancul and Rozenfeld

(2005), Paula and Cheng (2005), Trim and Pam (2005), Delgado Neto (2005), Barbalho (2006), Paula and Ribeiro (2007), Ottenbacher and Harrington (2007) and Marion and Simpson (2009). Therefore, the present work aims to answer the following question: Which is the most appropriate NPD model for electronic TBC?

The purpose of this work is to choose a model for the NPD of the electronic TBC. The study object is the LPS (Local Productive Settling) of Santa Rita do Sapucai, in the South of the Minas Gerais State, in Brazil, through the application of a decision-support method, that is, the AHP (Analytic Hierarchy Process).

There are many methods for decision support by multiple criteria (MCDA – Multiple Criteria Decision Aid). However, the AHP method is chosen in the present work since it presented in Salomon (2004), a superior performance regarding efficiency and coherency, which may or may not be due to proper software.

Firstly, specific characteristics of such an industrial sector are identified. Those features encompass their peculiarities and what these peculiarities have in common with the product development process from other sectors. Eventually, an analysis of the real needs during a product development process is carried out, being that these criteria are relevant to the entire development process. By this definition, these criteria are classified according to the significance order by NPD experts, and through the application of the AHP, it is determined which optimum model to be used by the industry in question.

The significance ranking process used in the decision-support method is carried out through observed information collected in TBC, which considered accomplished and current projects, team experience and evaluation of NPD experts.

2. Research methodology

According to Berto and Nakano (1999), the methodological approaches are divided into two groups, qualitative and quantitative. The quantitative approaches have hypothesis and are based on deductive logic, trying to explain cause and effect relationships and, through result generalization, allowing replications. Usually, the kinds of research are: experiments, survey, modeling and simulation. On the other hand, the qualitative studies intend to approximate theory and facts, through subjective analysis, which one usually gets results that allow comparisons among phenomena. The most used kinds of research in this case are: Case Study and Action Research.

To achieve the objective of this work, it is necessary to identify decision criteria and alternatives and to attribute importance values to these criteria and alternatives. Therefore, results are obtained and analyzed. By considering these conditions, this work approach is the modeling defined by Bertrand and Fransoo (2000), characterized as a quantitative research.

3. Technology based companies and the product development process

Candi and Saemundsson (2008) defined technology-based companies as ones that have found their business in new product development, oriented to the application and systematic use of advanced scientific and technology acknowledgements. A similar definition was proposed by the National Association of Promoters Entities of Innovation Business (ASSOCIAÇÃO..., 2002): technology-based companies are the ones that have a process or product resulting from scientific research and whose added values come from advanced technology areas such as: information technology, biotechnology, chemistry, precision mechanic, new materials, etc.. They can be defined by the application of scientific acknowledge, complex techniques domain and high technical qualification job.

It was identified that research and development are prevailing characteristics of technology based companies.

Clark and Fujimoto (1991) defined the process (NPD) as the one that the company transforms market opportunities and technical possibilities into goods and information for a commercial product manufacturing. In the TBC, the NPD presents peculiarities, because besides it identifies the market needs to be served, any product concern, there are some needs related to planning how the technologies will be developed and incorporated to the products (MARKHAM, 2002). Löfsten and Lindelöf (2005) described in their research the main rule of the technology innovation in the NPD of technology-based companies. Hung and Tang (2008), through survey and later logistic regression, confirmed that innovation is the most important characteristic for technology acquisition in electronic companies in Japan, Korea and Thailand. However, according to Hazelrigg (1998), the decision process in the NDP is relevant and a subject largely approached by Cooper (1994). So, criteria for product development process in technology-based companies were identified: innovation, integration and decision process.

In the end of the research about technology-based companies, it was identified an opportunity to study models of product development for these companies, once this approach was not found among the works consulted in this bibliographic review.

4. Electronic technology-based companies

According to public diagnosis (FEDERAÇÃO..., 2007), electronic sector is one of the most important one in the economics reality. Synonymous of technology, it approaches all industrial sectors, bases all modern services,

restructures personal, professional and family lives, being main responsible by the spread of innovation, productivity, costs and prices reduction and establishment of "information society".

The choice of a product development model is to attend the LPS of Santa Rita do Sapucai, in the South of the Minas Gerais State, in Brazil, which corresponds for 70% of the national market of broadcasting and is one of the pioneers in the research of signal transmission for digital television. This LPS is formed by around 120 companies, which are mainly connected to: telecommunication and -electronic.

These companies' reality regarding project management is about using their own spreadsheets and programs, including local software, which integrates fiscal, financial and material management. Around 57% of these companies create their project management methodology. These methodologies are developed through accumulated and systemized experience that are transformed into procedures, which one frequently does not aggregate all the necessary aspects such as risk management, customer relation, technical and human resources management that are expected and that are found in methodologies based on best practices, for example, the one established by Project Management Institute (PMI). This way, it is clear and justified the need for a selection of a model for a product development process to the APL.

Only 12% of the LPS companies use PMI practices and 28% do not use any methodology. This indicates a great potential for a methodology development, based on devoted or improved practices, in order to allow the management improvement in these companies. Another information obtained from this diagnosis is that 87% of the LPS companies are micro or small companies, which correspond to 54 and 33%, respectively.

The definition of a reference model for new product development for technology-based electronic companies can contribute, as follows:

- Companies in the sector start to execute the new product development formally and systematically, integrated with other business processes, other participants of supply chains and final customers.
- Resources are supplied to companies so that they can innovate and develop new products inside their factories.

5. New product development models

Actually, there is a bigger focus in the scientific research on pointing out not only what is common among several product development models, rather than on characteristics that make them different from one another, but also on what is more adequate for a kind of business. For that being so, the main result from application of AHP in this research is a selection of a reference model, which is the most appropriate to electronic TBC. Therefore, it is necessary a definition about reference models.

According to Vernadat (1996), reference models are partial models that can be used as a base to the development or evaluation of specific models. They are called partial because they do not meet an existent process in a certain reality. Regarding Browning, Fricke and Negele (2006), a model is an abstract representation of a reality that is built, verified, analyzed and manipulated to increase the comprehension of this reality. The models can be hold in mind (mental models) or can be codified.

The research accomplished by O'Dwyer and Ledwith (2008) showed that small companies should be aware of the strong relationship between the new product performance and the whole company performance. The companies that are good in developing new products are the ones which obtain the best results. In addition to that, the analysis shows that companies that are good in launching products have bigger probability in succeeding with a new product. This information is important to small companies. Besides, small companies need to know their competitors, that is, orientation to competitors are linked with the performance of a new product and company performance. In other words, small companies need to know when and why customers decide to buy from competitors and also what attracts them to their products.

The process models can be built due to a diversity of reasons. Traditionally, process models supply a base for planning and controlling projects. By identifying activities to be done and their mutual dependency, project managers can start to have a clue about the critical path of a project and about its length. Schedules are the traditional focus on projects, and this application of process models largely reaches the project management community (BROWNING; FRICKE; NEGELE, 2006).

Still looking for a definition, according to Barbalho and Rozenfeld (2004), reference models should consider the proposal idea in order to level the vision about a reality, because for them, a model never totally describes a reality. It is also necessary to define a model user. Besides, according to these authors, the model should be an external and clear representation, in a way that it can be shared with different people. Hence, a reference model can be defined as the union of the best practices related to a specific development process, being that these practices are represented clearly by any user of this process.

From the definitions above, it is possible to advance to the analysis of some models. Salgado (2008) showed that each author interprets new product development from a different view. Table 1 presents the abbreviation that will be used throughout this study with reference to each model and its respective author.

Table 1. Acronym for the NPD models.

Acronym	Author
BAC	Back (1983)
VIN	Vincent (1989)
ROS	Rosenthal (1992)
WCL	Wheelwright and Clark (1992)
CED	Cooper and Edgett (1999)
PAH	Pahl et al. (2005)
ROZ	Rozenfeld et al. (2006)

From these models identified in the literature, it will be presented a selection of a proper model to the electronics TBC.

6. Multiple criteria decision aid

As defined in Section 1.2, the approach of the present research is quantitative, using modeling as its method. According to Szajubok, Mota and Almeida (2006), the main characteristic of quantitative models is the fact that they can be examined by mathematical analysis techniques. The application of these techniques is especially necessary to obtain, in a certain extent, a structured decision to the problem in question.

As reported by Saaty (1980), the decision-making in a complex environment involves the consideration of multiple criteria. Therefore, in a context that multiple criteria will be considered in a judgment, the quantitative approach is suggested through math analysis, and it will be applied through a multiple criteria decision aid method.

The choice of a specific method to be applied depends on the type of the problem under analysis, the context which is being studied, the authors who are involved, the preferences and the kind of answer and result that are wished to be achieved, that is, what the problem in reference is all about (GOMES; GOMES; ALMEIDA, 2002). According to Bana e Costa (1988) and Vincke (1992), the MCDA approach can be classified by: unique synthesis criteria; local interactive approach; and subordinate approach.

In this specific research, it has been considered the unique synthesis criteria approach, which has the purpose of finding a unique function that aggregates the different utility functions. The methods that are based on this approach are classified as part of the MCDA American School. Among the method and theories based on this approach, one may mention: AHP (SAATY, 1980), the Social Choice Theory (ARROW, 1963) and the Multi-Attribute Utility Theory (MAUT)

The AHP is chosen as the criteria decision aid method to be used in this research. According to Braglia et al. (2006), the AHP represents one of the safest approaches that the multi-criteria decision uses for problem decision and method application. According to Wang, Chu and Wu (2007), the AHP is the most popular method of multi-criteria decisions and allows the measure of the decision judgment coherency.

In the research performed by Salomon (2004), it was identified that among the following decision aid methods, AHP, ELECTRE I and MACBETH, the first one presented a better performance related to efficiency and coherency issues, although there was no need of a proper software to identify this advantage. In practical applications of MACBETH method, there is a smaller technology domain of the MCDA from users of decision aid when compared to AHP method applications, because the MACBETH method application is just possible when it is used through a proper software. The ELECTRE I method does not allow verification of judgment coherency, once this verification has the objective of analyzing data quality. With the intention of emphasizing reasons for the choice of AHP as the decision aid method used in this research, in the following there are relevant issues from this method, previously cited as some characteristics identified by Guglielmetti, Marins and Salomon (2003):

- Unique synthesis approach, that is, it looks for a unique function that aggregates others.
- Enabling of judgment coherency evaluation of decisions.
- No need of proper software.
- Accomplishment of judgments until nine alternatives.
- Enabling of work with qualitative and quantitative data.
- It is not necessary to process data before they are used.
- Presentation of a complete rank of alternatives.
- It is not necessary to be a specialist in the method to use it.
- It is easy to use the tool by the decision maker.
- Results are clearly presented.
- It is largely used in scientific publications.

According to Saaty (1980), the AHP is a decision aid method using multiple criteria. The AHP can be recognized as a powerful method to solve problems of multi-criteria decision making in several areas and sectors for the selection and hierarchy, according to researches of: Huang, Chu and Chiang (2008); Bozbura, Beskese and Kahraman (2007); Salomon and Whittaker (2007); Chin et al. (2002); Hsu, Tzeng and Shyu (2003); Kang and Lee (2007); Aguiar and Salomon (2007); Ngai and Chan (2005); Partovi (2007); Wei, Chien and Qang (2005); Melon, Beltran and Cruz (2006).

According to Shimizu (2006), the AHP method has been used in the following situations: priority definition, cost and benefit evaluations, resource allocation, performance measurement, market research or evaluation, requirement determination, strategic decisions, planning and sequence of

activities, conflict resolution and trading, policy and social decisions and risk decision analysis.

Thus, regarding those advantages of AHP method, it is going to be used here as a method for the selection of a proper model for technology-based electronic company.

Articles such as Mohanty et al. (2005), Hsu, Tzeng and Shyu (2003) and Calantone, Benedetto and Schmidt (1999) propose AHP application in order to select and rank product projects for companies. In doing this, it is possible to consider this principle and use this method to the selection of a product development method. The use of such method starts with the definition of a final objective, which has to be chosen. From this point on, the next step is to define the criteria or the specific factors of evaluation that will guide the choice.

7. Method application to the product development model selection

In order to apply the method, not only is support necessary from specialists in the area of project management and product development, but also interest in the development of a specific model.

As a preparation step for AHP application, there is the need of two priority definitions: the final objective of choice and the evaluation criteria. First of all, the final objective of choice can be described as a product development model, which is particular to technology-based industry, and also specific to electronic companies.

The second step is the criterion definition. These factors will determine which model is more appropriate to the industry under study. The evaluation criteria are then determined together with the specialist support and are also based on literature research related to the industrial sector being studied. The criterion choice is based on:

Innovation: industry innovation (creation and development of products);

Process integration: NPD integration with other processes of the company.

Decision process: support to decision process. Supply of information to performance control as well as support to management decisions, information about process and development perspective.

By evaluating such models through AHP method, the Fundamental Scale defined by Saaty (1980) is then used. Consequently, the criterion priority is chosen, as presented in Table 2.

It is important to emphasize that the Innovation criteria have the weight clearly bigger than the other criteria, once this is an important characteristic related to technology-based industries. The other criteria represent the integration of the development process with the other processes in the industry, allowing the company to make use of this development process as a source of strategic information and decision. The weight of these criteria shows the evolution of the NPD and the alignment with the actual needs of the companies in taking decision faster in a competitive market.

Still considering the same value scale, judgment is carried out by specialists for each relation of criteria versus model, presented in the Tables 3 to 5.

In the Table 6, it is presented the final ranking of the AHP application. Therefore, according to the result through the application of this method, the model presented in Rozenfeld et al. (2006) is chosen as the reference model to TBC of electronic sector, in the APL under study.

Besides the final classification, it is important to observe the sensitivity among every judgment. According to Figure 1, it is identified that there is an inversion in the choice, if the weight of Decision Process comes from 33.3 to 48%.

8. Discussion and conclusion

It has been observed a trend in the recent academic research that focuses on product development models applied to specific industrial sectors. Specifically to the APL under study, in the electronic sector, it is important

Table 2. Priority of the criteria.

	Innovation	Process Integration	Decision Process	Weights
Innovation	1.0	5	2	57.0%
Process Integration	0.2	1	0.25	9.7%
Decision Process	0.5	4	1	33.3%

Table 3. Judgment according to Innovation.

Innovation	**BAC**	**VIN**	**ROS**	**WCL**	**CED**	**PAH**	**ROZ**
BAC	1	2	2	1/4	1/7	1/3	1/7
VIN	1/2	1	2	1/5	1/5	1/2	1/7
ROS	1/2	1	1	1/7	1/8	1/3	1/8
WCL	4	5	7	1	1/2	5	1/5
CED	7	5	8	2	1	7	1
PAH	3	2	3	1/5	1/7	1	1/7
ROZ	7	7	8	5	1	7	1

Table 4. Judgment according to Process Integration.

Process Integration	**BAC**	**VIN**	**ROS**	**WCL**	**CED**	**PAH**	**ROZ**
BAC	1	8	9	2	2	5	1/2
VIN	1/8	1	2	1/4	1/5	1	1/8
ROS	1/9	1/2	1	1/5	1/6	1/3	1/8
WCL	1/2	4	5	1	1	4	1/3
CED	1/2	5	6	1	1	5	1/3
PAH	1/5	1	3	1/4	1/5	1	1/7
ROZ	2	8	8	3	3	7	1

Table 5. Judgment according to Decision Process.

Decision process	BAC	VIN	ROS	WCL	CED	PAH	ROZ
BAC	1	1	1	1/2	1/8	1	1/7
VIN	1	1	1	1/4	1/9	1	1/8
ROS	1	1	1	1/3	1/9	1	1/9
WCL	2	4	3	1	1/3	6	1/3
CED	8	9	9	3	1	9	2
PAH	1	1	1	1/6	1/9	1	1/9
ROZ	7	8	9	3	1/2	9	1

Table 6. Priorities for the NPD models.

	Innovation	**Process Integration**	**Decision Process**	**Decision Vector**
	56.95%	**9.74%**	**33.31%**	
BAC	4.48%	24.80%	4.51%	6.5%
VIN	3.96%	3.85%	3.94%	4.0%
ROS	2.96%	2.50%	4.04%	3.3%
WCL	16.79%	14.03%	13.15%	15.3%
CED	29.83%	15.35%	39.46%	31.6%
PAH	6.30%	4.45%	3.66%	5.2%
ROZ	35.68%	35.02%	31.23%	34.1%

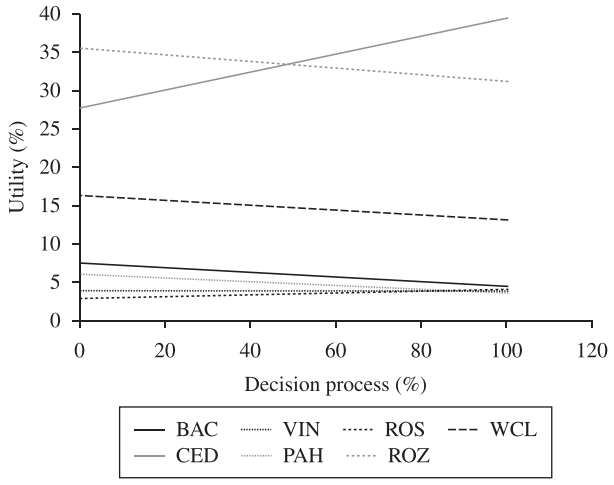

Figure 1. Sensitivity Analysis – Decision Process Criteria.

to adopt a specific product development model or to adjust the existing ones.

In this way, aiming to choose a generic NPD model to this type of industry, the AHP model was applied to some of the main models of product development cited in literature. For the present application, it was necessary to define some comparison criteria: innovation, process integration and decision process.

Thus, it was defined as a proper model to the technology-based company of the APL in question, that is, the Rozenfeld et al. (2006) model, which, according to the judgment of the specialists, aggregates in a more considerable scale, all the comparison criteria defined in this study.

It is relevant to say that the model presented in Cooper and Edgett (1999) (second model), enabled a small distance from the selected model (first model). These two models offered a higher classification when compared to the others, performing 66% of the final judgment. This observation can suggest that the model in Rozenfeld et al. (2006) could have been considered or incorporated by the other ones.

It is suggested for future research, to study specific models (adjusted) for product development in electronic TBC (according to this research, based on the reference model from Rozenfeld et al. (2006)); to define phases and activities of a reference model adjusted to electronic TBC, from the using of the decision support methods, in special, the AHP, which is justified by the reasons presented in this work; to enlarge the selection of NPD models from the NPD specialized analysts in Brazil and abroad; to make a diagnosis about the maturity level of the NPD in the electronic TBC.

It is possible to conclude that the current research achieved the main objective of selecting a NPD model for the electronic TBC, through AHP application, which is a decision aid method. This is the contribution of this research to the acknowledge base, since previous research selected reference models to be studied without an application of a similar method. It is expected that this work may bring researchers to start to use decision aid methods in similar researches involving reference models as the NPD.

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