

## USING ANALYTIC NETWORK FOR SELECTION OF ENTERPRISE RESOURCE PLANNING SYSTEMS (ERP) ALIGNED TO BUSINESS STRATEGY

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### ABSTRACT

The choice of an Enterprise Resource Planning (ERP) must be made judiciously by the high costs involved in the acquisition of such systems. Managers in areas such as accounting, financial and information technology need support and tools that help in selecting an appropriate ERP for their business. With this article, we present a study aimed at investigating the possibility of a Decision Support System (DSS) to be used for this selection interrelating evaluation criteria, which could allow to contemplate the strategic alignment between Business and Information Technology. From the literature review 28 factors related to the selection of software packages, with special emphasis

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on ERP were identified. For the research procedures, the qualitative ones were adopted, in that the 18 factors considered relevant to a good selection of ERP were classified with the Delphi technique and used as input in a DSS: Analytical Network Process (ANP), applied as a Case Study in a small business that hired the ERP. The results showed that the ANP was efficient in interrelated criteria and evaluated the strategic alignment between Business and Information Technology.

**Keywords:** Selection of Information System; Enterprise Resource Planning – ERP; Analytic Network Process – ANP

## 1. INTRODUCTION

Enterprise Resource Planning (ERP) systems comprise a set of applications that enable companies to automate and integrate a substantial portion of their processes, involving finances, controls, logistics, purchasing, manufacturing, sales and human resources, making it possible to share data and to standardize business processes, in addition to producing and using information in real time (Turban, Leidner, Mclean, & Wetherbe, 2010; Laudon & Laudon, 2011; O'Brien & Marakas, 2013).

Because ERP systems have a high cost of licensing and implementation, and a high degree of uncertainty regarding results, acquisition thereof generates insecurity among decision-makers at the time of selecting a system for the organizations, and is therefore a complex and non-structured decision (Turban et al., 2010).

Cases of failure in the implementation of integrated management systems at large corporations are frequent and widely known by the Information Technology (IT) community. According to Ganly (2011), studies by Gartner Research show that 20% to 35% of the implementations fail and that the outcome for up to 80% of the projects are questionable, because they overrun the proposed deadlines and/or budgets.

Better developed and friendlier solutions in terms of parameterization, better training of consultants, and greater awareness by companies regarding Critical Success Factors (CSF) in the implementation of systems have all contributed to reducing such failures.

From the high number of questionable projects, however, one can deduce that there are still many gaps to be filled, evidencing the need for better management, not only for implementation planning, but also for selection when acquiring the system.

Ganly (2011) considers the six major pitfalls in the implementation of an ERP system: 1) inappropriate or insufficient scope of ERP; 2) lack of commitment by managers; 3) insufficient or inappropriate budget; 4) inappropriate administration and training; 5) inexperienced management and project team; and 6) extensive modifications. With the exception of the second item, the others are the result (albeit indirectly) of poorly developed projects and poorly routed acquisition.

Accordingly, with this article we sought to answer the following research problem: **How to formulate a decision-making procedure for the selection of an Enterprise Resource Planning system aligned to the business that allows interrelation of evaluation criteria?**

The relevance of this topic is evident, since there is still a considerable number of companies that have not yet used ERP software packages to integrate the data and processes of their departments in a single system. Studies by the Center for Information Technology and Communication Studies (CETIC, 2011) – an organ of the Brazilian Internet Steering Committee – show that the proportion of these companies represented, on average, 61% of all enterprises in 2010 and that, even at companies with over 250 employees, 27% do not use ERP (table 1).

**Table 1** - Proportion of enterprises that use ERP software packages to integrate data and processes of their departments in a single system.

Porte	Yes	No	DK/NR
Total	35	61	4
10–49	31	65	4
50–249	51	46	3
250 or more	72	27	1

Source: Adapted from CETIC (2011)

The overall aim of this article is to propose a model supported by a Decision Support System (DSS), which allows companies – whenever there is an interest in acquiring an Enterprise Resource Planning system – to analyze which of the available offers will be most suited to their business strategies.

## 2. THEORETICAL REFERENCE

### 2.1 Investments in Information Technology and Information Systems

According to Perez (2007), organizations in the age of information and knowledge have been investing higher amounts increasingly in Information Technology (IT) and Information Systems (IS), because IT and ISs have gradually become a significant component in practically everything that companies do (Turban et al., 2010).

Authors such as Lunardi, Becker & Maçada (2003), and Perez (2007) report that some sectors have invested heavily in IS and IT, and indicate competition and rivalry as the primary factors that justify this practice. Another factor related to investments in IS and IT is the pursuit of competitiveness and above-average returns.

Investments in IS and IT to obtain better security conditions have increased substantially in recent years, particularly in the financial sector. Applegate, Austin & McFarlan (2003) consider that investments in IS and IT can contribute to knowledge management; the results obtained in this case are: improvement in the performance of the knowledge of company employees and organizational learning.

### 2.2 Enterprise Resource Management (ERP)

Information Systems perform three major roles in all types of organizations (O'Brien & Marakas, 2013): 1) Support operations; 2) Support competitive strategies; and 3) Support decisions.

The support of operations is obtained mainly by transactional systems. The support of competitive strategies can take place through innovative uses of information systems. Decision support is ultimately made by managerial or executive information systems, by Data Warehouse and Data Mining resources, or by DSS (O'Brien & Marakas, 2013).

Highlighted among transactional systems is ERP, which can be conceptualized as being a comprehensive and integrated software package that enables the standardization and automation of business processes by using a unified database and real-time transactions. Implementation of ERP at companies eliminates the “islands of automation” (McFarlan & McKenney, 1982) that existed prior to this.

### 2.2.1 Reasons for Adopting ERP

The option of adopting an ERP system – despite the fact that it is a common desire of top executives of all companies – is always a complex decision. However, one can clearly see that there are often expectations beyond what the applications typically offer. Colângelo (2001) considers that there are three classes of reasons that lead a company to implement an ERP system:

- **Business:** aims to increase profitability and strengthen the organization's competitive position.
- **Legislation:** aims to meet the legal requirements that the company must comply with and not fulfilled by legacy systems (those in use at the company).
- **Technology:** aims to meet the necessary changes resulting from economic obsolescence of technologies in use or the requirements of business partners.

However, there are several common minimum expectations (Koch, 1999; Colângelo, 2001), the most mention-worthy of which are (among others): a) Managerial or executive information; b) Integrated financial information; c) Reduction of inventory; and d) Lack of integration among legacy systems.

### 2.2.2 Critical Success Factors in Implementing ERP

Critical Success Factors (CSFs) represent a mechanism for identifying information needs by the managers of organizations. For Rockart (1979, p. 85), “CSFs are, for any business, the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization.” These are the few key areas where “things have to go right” for the business to succeed.

Esteves-Sousa and Pastor-Collado (2000) compiled the CSFs found in the literature, in ten studies based on the analysis of reports on deployment of Enterprise Resource Planning systems. They determined the similarities and common patterns among them, and proposed the unification thereof according to the model shown in Figure 1.

	Level	Perspective	FCS
Organizational	Strategic		Continuous support from company management. Management of effective organizational changes. Management of a good project scope. Appropriate composition of the project team. Comprehensive process of business reengineering. Role of the project sponsor. Participation and involvement of the users. Reliability among partners.
		Tactical	Dedication of the work group and consultants. Strong internal and external communication. Design and scheduling of formal implementation. Appropriate training program. Preventive troubleshooting. Appropriate use of consultants. Authorized decision makers.
Technological	Strategic		Appropriate strategy of implementation. Avoiding customizations. Appropriate system version.
		Tactical	Appropriate configuration of the software. Knowledge of legacy systems.

**Figure 1.** Relevance of the CSFs per perspective.

Source: Esteves-Sousa & Pastor-Collado (2000)

### 2.2.3 Selecting an ERP platform

Selecting ERP suppliers is a complex task that requires an effort on the part of the contracting enterprise, under penalty of failure and generation of an environment of animosity in the customer-supplier relationship, if the selection does not abide by the pre-established criteria (Perez & Zwicker, 2005). Thus, more than merely seeking suppliers, companies must seek lasting partnerships with their suppliers.

Perez & Zwicker (2005) emphasize that technological training, the prospect of a lasting relationship, ethical stance, excellence of the services provided, and expandability of future solution offerings are, among others, relevant factors and should be taken into account when choosing a supplier. Due to its characteristics, the selection of an application such as ERP must follow criteria previously defined by managers/decision makers.

Mendes & Escrivão Filho (2007) present a roadmap considered as ideal for acquiring ERP systems and that allows an assessment of the adaptations and impacts on the changes of the organization. The aforementioned study, however, offers no guidance on the choice of system or supplier.

The selection process usually starts by issuing a Request for Proposals (RFP), which is an invitation to potential suppliers to submit their offers of specific products or services to the organization. This document is a questionnaire that involves the organization's requirements, not only regarding price, but also including more in-depth information about the supplier of the product or service, such as: financial data, technical

competence, forecast for implementation, business references and, primarily, details about the product in order to verify its degree of fulfillment of the purchasing company's business needs. The requirements vary from company to company and often reach hundreds of items to be analyzed.

### 2.2.3.1 ERP Selection Criteria

Figure 2 shows the results of research in the existing literature on the criteria most often considered in the evaluations. These criteria can be used in DSS, with the purpose of evaluating which ERP platform would be the most appropriate to the purchasing company.

	Teltumbde (2000)	Baki et al (2005)	Kumar et al (2002)	Illa et al (2000)	Fitzgerald (1998)	Corrêa (1995)
1. Technical criteria	X	X	X	X		
2. Functionality	X	X	X	X		
3. Supplier's references	X	X	X			X
4. Cost	X	X			X	X
5. "Implementability"	X	X			X	
6. Ease of customization		X	X			X
7. Cross modular integration		X	X			X
8. Consultancy of selection and implementation		X		X		X
9. Strategic fit	X				X	
10. Risks	X				X	
11. Flexibility	X				X	
12. Analysis of benefits	X				X	
13. Service and support		X	X			
14. System reliability		X	X			
15. Best fit with the organizational structure		X	X			
16. Fit with the system of the parent company and/or partners		X	X			
17. Method for deploying software		X				X
18. Supplier's knowledge domain		X				X
19. Supplier's position on the market		X				X
20. Compatibility with other systems		X				X
21. Supplier's vision		X				
22. Administrative changes	X					
23. Implementation Time		X				
24. "Scalability" to allow for growth						X
25. Technology upgrades						X
26. Ease of use						X
27. Security						X
28. Localization						X

**Figure 2.** Selection criteria identified

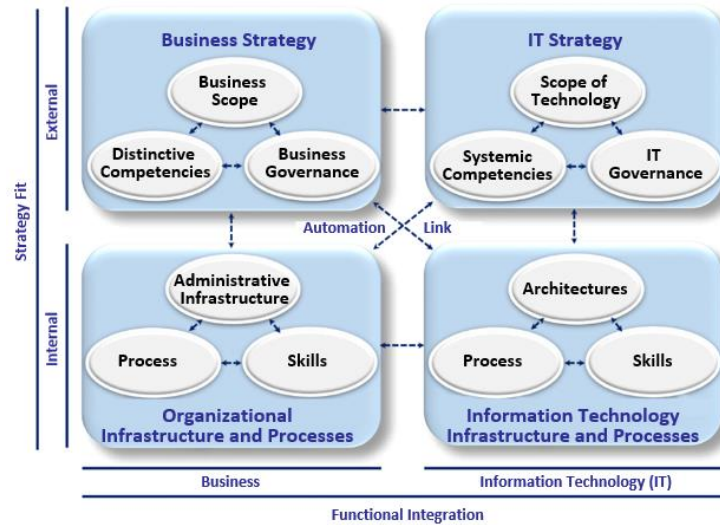
Source: Based on the literature researched.



### 2.4 Strategic Alignment of IT with the Corporate Strategy

According to Chan & Huff (1993), strategic alignment is the integration of IT with an organization’s key strategies and core competencies.

Henderson & Venkatraman (1993) developed a model to analyze the strategic alignment of IT with corporate strategy, which presents four blocks that represent the four domains of the strategic choice (Figure 3).



**Figure 3.** Strategic alignment model  
 Source: Adapted from Henderson & Venkatraman (1993)

The pair of blocks on the left focuses on Business, while the pair on the right focuses on Information Technology. From another standpoint, the upper pair (of the external domains) represents Strategy, while the lower pair (of the internal domains) represents Infrastructure. The interrelationship is such that any strategic decision involves decisions in one or more domains.

One domain guides or impacts activities in one or more of the other domains. The business strategy, for example, impacts the organizational infrastructure, and the IT strategy impacts the IT infrastructure. This model allows organizations to analyze in which domains they are strong or weak, and the effects of a decision on one domain on the others.

Although strategic alignment is usually done in the external domain, i.e., in the relationship between business strategies and IT strategies, this does not mean that the internal domain (relationship between organizational infrastructure and IT infrastructure) is secondary or any less important. Consider two types of integration between the domains of business and IT. One is strategic integration, which links business strategy to IT strategy, reflecting the external domains. Another is the functional integration, reflecting the internal domains, which link the organizational infrastructure to the IT infrastructure.

Each domain also contains three sets of choice, as identified in Figure 3 and described in Figure 4. Henderson & Venkatraman (1993) consider that strategic alignment is a simultaneous result of both a strategic fit and a functional integration.

The strategic fit is obtained when decisions are made, which properly position the company on the market, when in the business domain, or technologies at the company, when in the IT domain. A good strategic fit allows the structure, processes and people skills to be capitalized in the implementation of the organizational strategy, in the Business domain or of technology in the IT domain (Luftman, Lewis, & Oldach 1993; Curtin, 1996).

<b>Business</b>	<b>Information Technology</b>
<p><b>Scope of the business:</b> The decisions and choices that define the company's field of competition, such as: products, niche, customers, etc. Includes the competitive forces proposed by Porter (1989). The typical questions are: what is our business? What are our products, services and target markets?</p>	<p><b>Scope of technology:</b> Specifies the critical technologies responsible for the organization's success, such as knowledge base systems, robotics, multimedia, etc. The typical question is: what technologies not only support but also create strategic business opportunities?</p>
<p><b>Distinctive competencies:</b> These are the areas that determine how companies will compete in delivering their products or services. It is the company's ability to differentiate its products or services from the competition. The typical question is: what we should focus on doing better in order to distinguish ourselves from our competitors?</p>	<p><b>Systemic competencies:</b> Important characteristics of IT that are critical in the creation or extension of business strategies, such as connectivity, accessibility, reliability, etc. The typical question is: what characteristics of IT create business advantages?</p>
<p><b>Business governance:</b> These are decisions relating to possible partnerships or outsourcing, in order to obtain advantages of scale for catering to a particular market. The typical question is: what relationships with external business and/or joint ventures do we depend on?</p>	<p><b>IT Governance:</b> Defining the ownership of the technology (end user, management committee, etc.) or the possibility of technological alliances such as partnerships, outsourcing, or both, or make-or-buy decisions. The typical question is: what external relationships such as outsourcing, make-or-buy decisions, etc., do we depend on?</p>

**Figure 4.** Strategic alignment model

Source: Adapted from Luftman, Lewis & Oldach (1993) and Curtin (1996)



	Business	Information Technology
I n f r a s t r u c t u r e	<p><b>Administrative infrastructure:</b> These are choices that establish the framework of management and work processes that a company will operate. It is the framework of rules, responsibilities, and powers of the company. Typical questions are: what is our organizational structure? Who reports to whom?</p>	<p><b>Architectures:</b> These are the choices, priorities or policies that synthesize the applications, data, hardware and software into a cohesive platform. The typical question is: what are our options of platforms, hardware, software, network settings and data architecture?</p>
	<p><b>Processes:</b> There are choices that determine how the basic business functions will operate or flow. Define how restructured or integrated the workflows will be in order to improve the efficiency and effectiveness of companies. The typical question is: what are our key business processes?</p>	<p><b>Processes:</b> This is the configuration as to the practices of application development and management control of the systems. The typical question is: what are the IT processes: development, maintenance, system operations, database administration?</p>
	<p><b>Skills:</b> These are choices where human resources involved in the strategy and the need to hire outsourced services must be clearly defined. The typical question is: what human resources do we have (or do we need) to keep up with our specific competitors?</p>	<p><b>Skills:</b> These are the experiences, competencies, commitments, values and standards that govern the tasks with the aim of production and delivery of IT products and/or services. The typical question is: what are the skills that our IT managers, and supporting staff need to keep the architecture and execute the processes?</p>

**Figure 4.** Strategic alignment model (cont.)

Source: Adapted from Luftman, Lewis & Oldach (1993) and Curtin (1996)

## 2.5 Decision Support Systems

According to Shimizu (2010), there are several methods that enable decision support, among which are the following:

- **Utility theory** assumes that a decision-maker always seeks the solution that generates the greatest satisfaction or “utility” (i.e. usefulness) for them.
- **ELECTRE methods** (from the French acronym for *Elimination et Choix Traduisant La Réalité*): a decision-making algorithm for problems with multiple criteria, which reduces the size of the set of possible alternatives, classifying them according to the criteria of dominance of one over the other.
- **MACBETH method** (from the acronym for “Measuring Attractiveness by a Categorical Based Evaluation Technique”): allows one to concentrate the various evaluation criteria into a single synthesis criterion by assigning weights to various criteria, respecting the opinions of the decision-makers.
- **Analytic Hierarchy Process (AHP) method:** the basic assumption of AHP is that a complex problem can be efficiently solved when it is broken down into several parts interconnected by a hierarchical structure, determining specific weights for each criterion – in a pairwise comparison – in order to rank the alternatives.
- **Analytic Network Process (ANP) Method:** enables the decision maker to consider the possible existence of dependences between decision

factors and analyze the effect and feedback arising from these dependences. This is obtained by judgment calls and use of measurements by proportional scales. While AHP is a theory that depends on the values and judgments of individuals and groups, based on a given scenario, ANP is a generalization of AHP (Saaty, 2001), since it allows the construction of different scenarios, for complex decision problems.

The main difference between AHP and ANP is that the latter is an approach that substitutes hierarchies for networks and, in both approaches to decision making, judgments are executed jointly in an organized manner to produce priorities. In ANP, interaction and feedback take place in clusters of elements with inner dependence, and between these clusters with outer dependence, better capturing the “complex effects of reciprocity in human societies, especially when risks and uncertainties occur” (Saaty, 2001).

ANP, by allowing the feedback of the judgment and due to its characteristic of allowing clusters, was chosen as a research instrument of the Case Studies, since ANP is a relatively simple multi-criteria method, with an intuitive approach that can be easily accepted by managers and other decision makers (Meade & Presley, 1999).

It can be applied with the use of electronic spreadsheets, such as Excel, but also allows for ease of use by applying the SuperDecisions software which can be downloaded from [www.superdecisions.com](http://www.superdecisions.com).

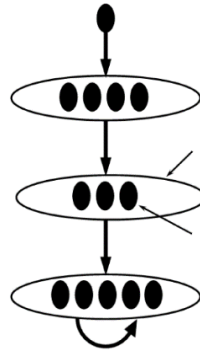
Feedback allows one to make a judgment not only regarding the importance of each alternative for each criterion, but also how these have their importance judged for each alternative.

In this study, it was not intended to compare DSSs. The aim was to determine whether there is the possibility of obtaining a selection of ERP aligned with business strategies using a DSS. Therefore, we defined – albeit in a prescriptive manner – the use of ANP, since it allowed the formation of the grid according to Henderson & Venkatraman (1993) to be reproduced in the form of the clusters thereof.

These clusters contain the criteria to be judged according to the dependences between decision factors and to analyze the effect and feedback arising from these dependences. This is obtained by judgments and the use of measurements by proportional scales for the distribution of influence between factors and groups of factors in the decision, enabling the allocation of resources according to the proportional scales of priorities.

Judgments in ANP are pairwise using a fundamental scale (also used in AHP), where intensity 1 indicates equal importance between the two activities, 3 indicates moderate importance, 5 indicates strong importance, 7 indicates very strong importance, and 9 indicating extreme importance. Even-numbered intensities indicate intermediate importances between the odd-numbered intensities, and the reciprocal values are used if an initial activity compared to a second activity has a value equal to one of the intensity values indicated, then that second activity has the intensity value reciprocal to the first (Saaty, 2000, 2001, 2005).

According to Saaty (2005, p. 47), two questions must be answered: “1) Given a criterion, which one of two elements is more dominant regarding the criterion? 2) Which of the two elements most influences a third element regarding the criterion?”



**Figure 5.** Abstract representation of the components of a decision in a hierarchical manner.

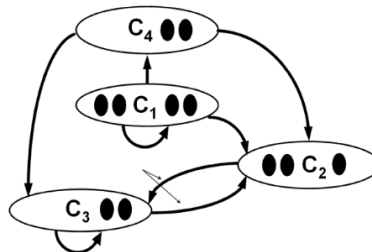
Source: Adapted from Saaty (2005). The simplest model has a cluster called “goal,” containing a “goal” element, a cluster called “criteria” containing the “criteria” elements, and a cluster called “alternative” containing the “alternative” elements, as shown in Figure 5. When the clusters are connected by a line, this means that the nodes (elements) are connected (Saaty, 2001).

The direction of the arrow indicates the comparison relationship of the clusters. Therefore, a two-way arrow indicates that sub-criteria influence the alternatives and vice versa. The arc-shaped arrow under the “alternatives” cluster (indicating a loop) means that the elements contained therein influence one another. The elements contained in “criteria” and “sub-criteria” were considered independent. The performance of one alternative can influence that of another alternative. The performance of one criterion on a sub-criterion, however, is not dependent on the performance on other sub-criterion (Salomon, 2004).

### 2.5.1 Fundamental components of ANP

#### 2.5.1.1 Dependences

In an ANP, the components can influence other elements in the same component. This is called inner dependence; with other components, it is called outer dependence.



**Figure 6.** Abstract representation of the dependences in a decision network.

Source: Saaty (2005) In Figure 6, the line between components C4 and C2 indicates outer dependences regarding common properties of the elements in C2 regarding the

elements in C4, while the loops in components C1 and C3 indicate inner dependence in common properties of the elements in these components (Saaty, 2005).

In order to avoid very complex networks, the ANP allows a cluster to be composed of a sub-network, which contains new clusters and respective nodes.

### **2.5.1.2 The Supermatrix**

The supermatrix consists of blocks of vectors of priorities for the clusters in the network, which are arranged in the supermatrix from the top down starting on the left side. Under each cluster are the nodes belonging thereto; the same thing occurs with the lines (Saaty, 2005). The comparison between all the linked clusters results in a matrix of global reach, which is used to weight the blocks of clusters in the supermatrix.

While the supermatrix is not weighted by the matrix of global reach of the clusters, it is called “unweighted supermatrix”. The sum of the values in the columns will be greater than one in those that contain a node that is compared to another in an inner dependence. After the weighting is applied by the global-reach matrix of the clusters, it becomes a “weighted supermatrix.” In this case, the effect of the weighting causes the sum of each column of the supermatrix to have a value of one (Saaty, 2005).

If the ANP design is created with sub-networks, each one will have its own supermatrix.

## **3. METHODOLOGICAL PROCEDURES**

### **3.1 Research Techniques**

The research involved the combination of two techniques of a qualitative nature, by means of the Delphi technique and the Case Study strategy. With the Delphi Technique, we sought – through consensus of a group of specialists – to classify the criteria that should be considered the most appropriate in the selection of an ERP system, while the second one aimed to verify the use of the procedure in a small business.

#### **3.1.1 Delphi technique (DT)**

This is an exploratory research approach (Hair, Babin, Money & Samouel, 2005). It is a qualitative analysis tool used primarily in situations in which there is a lack of historical data or technological breaks. An important aspect of the DT is to be an approach that seeks consensus among a group of specialists (Turoff & Linstone, 1975; Wright, 1986).

In the first part of the survey, the revised DT was used, as proposed by Dickson & Nechis (1984), prioritizing the key points in IS, to classify the relevant criteria for evaluating the ERP.

#### **3.1.2 Case Study**

Among the various qualitative research strategies, one can see that the Case Study is one of the techniques that has been used quite frequently for organizational studies, because it presents the possibility of a reflection of the results in the area of administrative sciences. This is a technique that involves an intensive and detailed study of a well- defined entity: the “case” (Coutinho & Chaves, 2002). According to Yin (2010, p. 19), the Case Study “is a preferred strategy [...] when the researcher has

little control over the events and when the focus is on contemporary phenomena inserted in some real-life context”.

#### 4. PRESENTATION AND ANALYSIS OF THE RESULTS

##### 4.1 Research Instrument Model

In order for there to be a reduction of factors, thereby avoiding the use of all 28 criteria shown in Figure 2, which would represent a high number of pairwise comparisons and make the application of the model unfeasible, the most relevant ones were obtained from two rounds of the Delphi Technique initially applied to 41 experts on the subject matter, out of whom 27 showed valid responses.

Accordingly, it was decided that the 18 most relevant assessment criteria indicated by the experts would be used in the ANP (Figure 7), which were then distributed among the clusters created in the SuperDecisions software according to the choices proposed by Henderson & Venkatraman (1993).

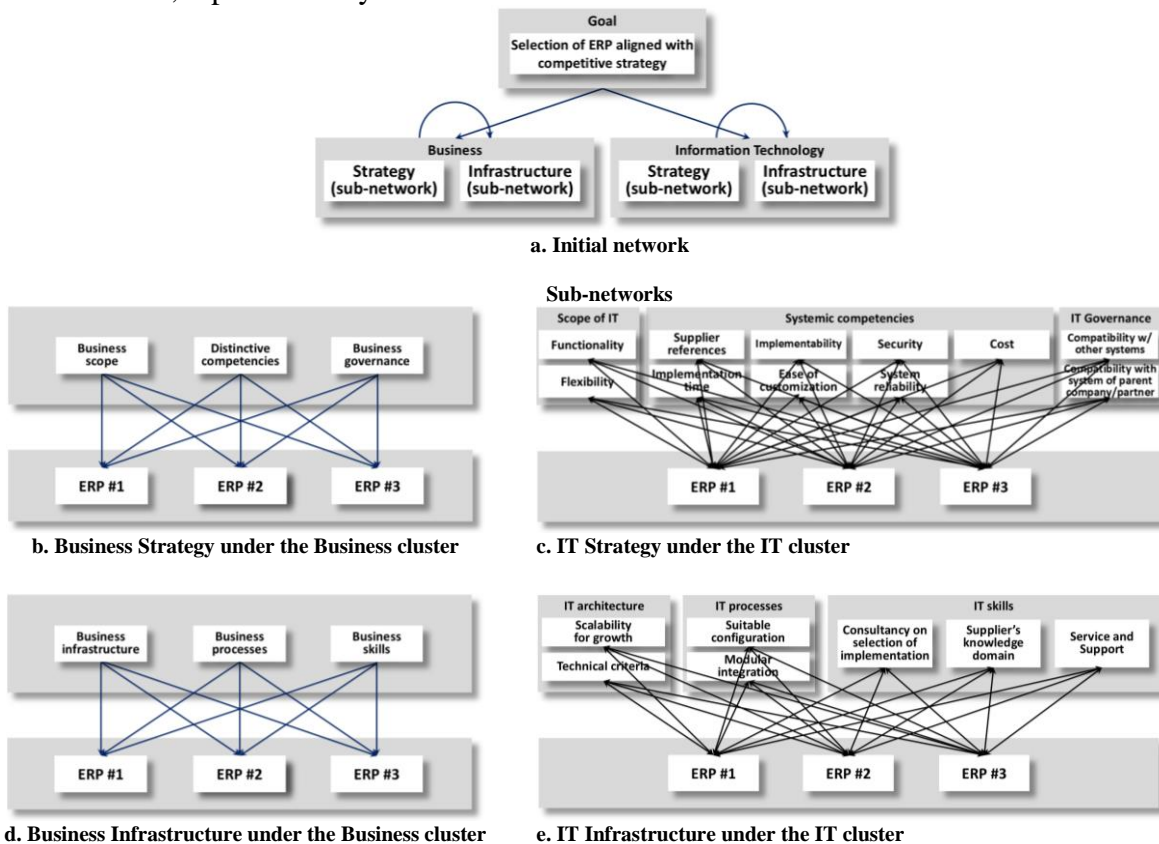
Sub-network	Choice	Criterion	
IT Strategy	Scope of IT	Flexibility	Denotes the system’s ability to support the business needs during its lifetime.
		Functionality	It has three principal aspects: 1) which functional areas the product can cover; 2) how flexible the product is regarding adaptability and openness; and 3) specific characteristics of some ERP platforms.
		System reliability	The system should incorporate the best business practices of each area, as well as the latest trends in IT. This reliability should be verified with the users.
		Cost	The price of an ERP system is usually very high. The Total Cost of Ownership (TCO) of the system must include the price of licenses, maintenance and upgrades, supplementary software, hardware, network, consultancy, training, implementation team, as well as other costs.
		Ease of customization	Even if one wishes to avoid customization, most companies need it, since there is a need to adapt a generic solution to the company’s specific needs. Customization can be done in-house, or by specialized consulting firms, or developed by the system producer itself, which is then incorporated into the main application.
	Systemic competencies	“Implementability”	Some projects are more difficult to implement than others. Some may never be able to effectively move ahead. The implementation of ERP systems also frequently demands redesign of the company’s processes, not only so that imperfect processes are not automated, but also so that the processes become adapted to the best use of the system.
		Supplier references	The supplier’s sales references, reputation, and international scope, with a track record of successful projects, should be considered as important criteria for the selection process.
		Security	Aspects related to data security and integrity should be considered when purchasing a system. Resources such as allocation and management of access passwords, protection against outside attackers, data backup and recovery support routines, and resources to deal with power outages during execution of routines are most outstanding.
	IT Governance	Implementation time	Implementation of an ERP system is highly costly and complex in large-scale projects. It is strongly correlated with the implementation strategy, and can also occur through changes in scope. Specific solutions can also reduce implementation time.
		Compatibility with the system of the parent company and/or partners	Compatibility with the system of the parent company and/or partners can affect the decision-making process of some companies. This compatibility can also affect the success of the project.
		Compatibility with other systems	No application can do everything a company needs. There is no such thing as absolute fulfillment. The selected solution must have resources for integration with the company’s legacy systems and other specialized software the company uses to cover all its needs.

**Figure 7.** Criteria for evaluating ERP attributed to the choices in the strategic alignment model in the sub-networks subordinate to Information Technology

<b>IT Infrastructure</b>	<b>IT Architectures</b>	Technical criteria	ERP is an IT application and its technological dimensions are important in environments of rapid technological changes, therefore, it must be up-to-date in IT trends, particularly as related to database management systems, client-server environment, hardware, operating system, etc.
		Scalability to allow for growth	Scalability allows ERP to grow gradually, according to the gradual growth of users at the company, allowing for increase in the capacity of hardware and software platforms in the same proportion, avoiding sharp discontinuities from complete changes of platform.
	<b>IT Processes</b>	Appropriate configuration of the software	Involves adapting the generic functionalities of a package to the particular needs of an organization.
		Cross modular integration	The real benefit of an ERP system is integration. And this integration should be complete among the modules. If this does not exist, aside from increasing the implementation cost, it may affect the efficiency of the system, which could decrease.
<b>IT skills</b>	Consulting services in selection and implementation	The consultants should have experience in the specifics of the company, with comprehensive knowledge of the modules, and be able to determine which system resources will best meet the company's needs.	
	Supplier's knowledge domain	It's important that the system developer has knowledge of the business segment. If the enterprise is a manufacturing company, it needs to find a software supplier specialized in its area of business.	
		Service and support	A complete installation of ERP can reach an investment many times greater than the cost of a software package. Therefore, the associated service and the support become crucial factors for the success of the business between the user and the supplier of a system.

**Figure 7.** Criteria for evaluating ERP attributed to the choices in the strategic alignment model in the sub-networks subordinate to Information Technology (Cont.)

Figure 8 shows the results, considering that there is dependence between and within clusters, represented by the arrows and the arcs.



**Figure 8.** Graphical representation of the network and sub-networks in the choice of ERP aligned with the corporate strategy used as a research tool in the Case Study.



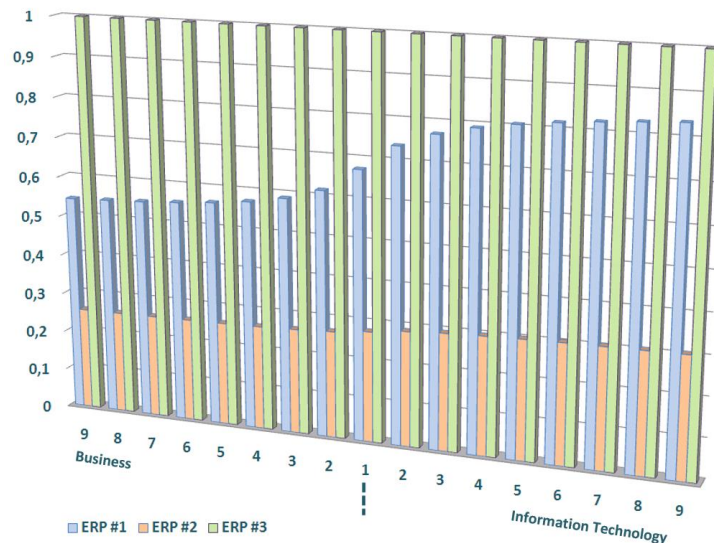
The model was reproduced in the SuperDecisions software whose graphic resources facilitate the understanding and control of the decision maker. A research protocol was prepared with all the possibilities of pairwise judgments and applied to a Case Study, with the manager of a company who had participated in deciding the choice of its ERP platform, from among three options (ERP #1 ERP #2, ERP #3) offered by the market.

We chose a small business that produces accessories for the automotive industry. The Case Study aimed to identify: 1) whether the ANP is suitable as a tool for analyzing the selection of ERP; 2) whether the use of the ANP built as the strategic alignment model (Henderson and Venkatraman’s model) allows the assessment to consider the respective importance of Business and IT assigned to the evaluation.

### 4.2 Results obtained

At the chosen company, the impact of the judgment between Business and IT was evaluated with the ANP, in order to verify that it would reflect the need for alignment between these two areas. Several simulations were carried out, and the impact of strategic alignment between Business and Information Technology was confirmed, as contemplated in the model developed by Henderson and Venkatraman (1991).

Graph in Figure 9 shows the simulation of the impact of the importance given by the company’s decision maker, where one can see that the best rated ERP after evaluation in the ANP (ERP #3) always has a value equal to 1, since this is the ideal result. The simulation shows that if the decision maker considers that IT is more important than the Business, then the possible decision for ERP #1 comes rather close ERP #3.



**Figure 9.** Ideal result (where the ERP with the best result – ERP #3 – has a value equal to 1), demonstrating that if the decision maker considers a higher intensity in IT, ERP #1 approaches ERP #3.



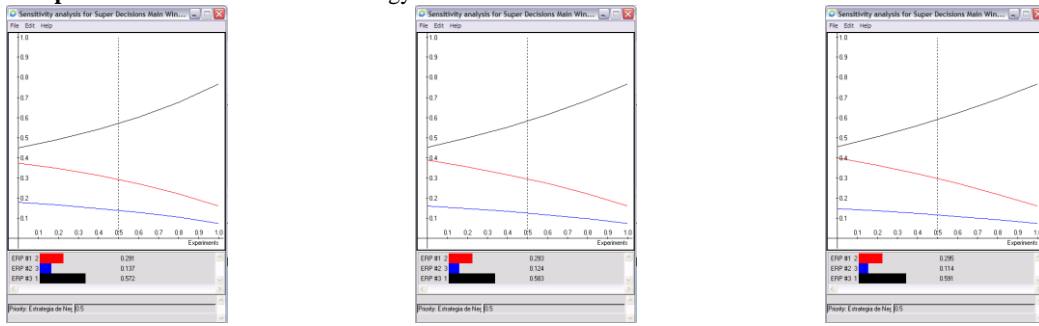
Sensitivity analyses were conducted, considering the results of the dependent variables (the ERPs) for the independent variables (the clusters) and also reflected this for the intensities of the judgment on the importance of the Business relative to the importance of IT within the organization.

The sensitivity analysis works with the “what if...” type of hypothetical scenarios, where the value of only one variable is changed repeatedly, and the changes occurring in the other variables are observed. This is done by repeated changes in only one variable at a time. This analysis enables an understanding of the impact of this variable on the others (O’Brien & Marakas, 2013).

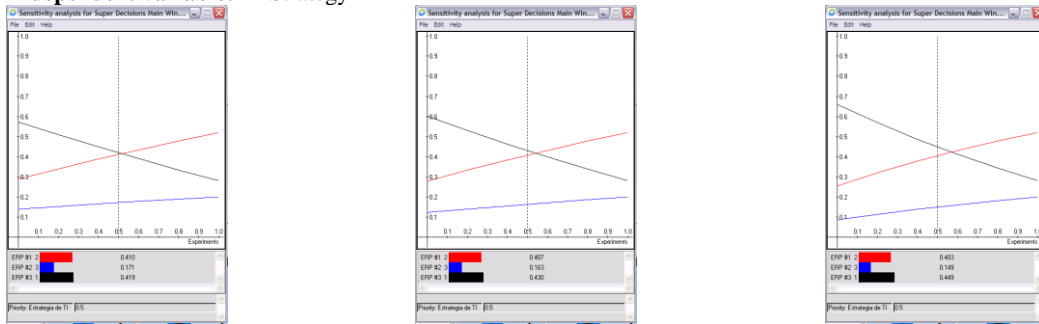
Saaty (2000, p. 112) considers that “a useful concern in any theory based on measurement is to hypothetically make both small and large perturbations in the measurements and note their effects on the outcome”.

Figure 10 graphically shows these sensitivities, extracted from the SuperDecisions software. One can see that despite the fact that ERP #3 showed a growing trend in direct relation to the experiments in Business Strategy, this does not occur in IT Strategy, in which – starting at grade 0.5 of the experiments – ERP #1 is classified in the first position. In IT Infrastructure, ERP #1 has advantage over ERP #3 when IT is evaluated as extremely important compared to the Business, however this position is inverted starting from grade 0.3 in the experiments. This demonstrates that the model is sensitive, because according to Turban et al. (2010) a model is sensitive when small changes in conditions determine different solutions.

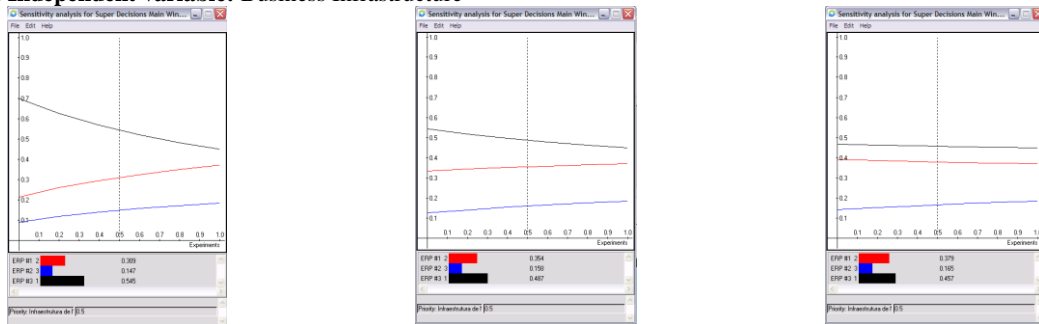
**1. Independent variable: Business Strategy**



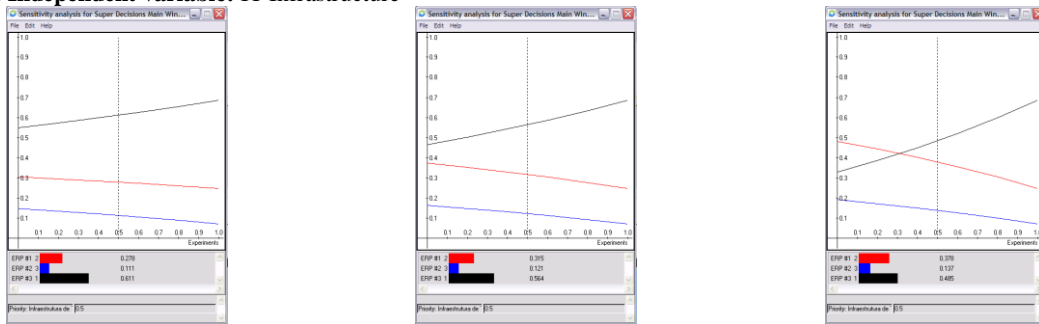
**2. Independent variable: IT Strategy**



**3. Independent variable: Business Infrastructure**



**4. Independent variable: IT Infrastructure**



a. Extreme importance of Business in relation to IT

b. Business and IT have the same importance

c. Extreme importance of IT in relation to the Business

**Figure 10.** Sensitivity analysis

## 5. CONCLUSION

The high cost and failed or questionable implementations have made the selection of an ERP system a challenge to business organizations. A recurring difficulty for managers is how to interrelate the various selection criteria to be considered. As a result, we developed this study with the aim of answering the following research problem: **How to formulate a decision-making procedure for the selection of an Enterprise Resource Planning system aligned to the business that allows interrelation of evaluation criteria?**

To carry out this study, the various criteria selected based on the literature were subsequently submitted to experts, who classified them according to their degree of relevance by using the Delphi Technique. Using the criteria identified by the research may be a good start, but each company has its peculiarities, which should be researched together with the master-users.

However, this procedure does not result in a *sine qua non*. The usefulness and applicability of the results obtained in the research reside precisely in the fact that specialists on the subject of ERP participated in it, who were able to transparently classify the criteria identified in the research, based on their knowledge and experiences acquired over time. As a result, companies can use them as a decision support tools in the acquisition of information technologies and systems, as is the case with ERP.

The sensitivity analysis is shown to be very useful to verify the robustness of the model, demonstrating that – depending on the intensities assigned to the clusters used as independent variables – an effective change of classification among the systems analyzed can occur. Saaty (2000, p. 112) considers that “a useful concern in any theory based on measurement is to hypothetically make both small and large perturbations in the measurements and note their effects on the outcome”.

However, one should consider that the system acquired is not always shown to be aligned with the corporate strategy. Aligning strategically does not necessarily mean considering equal importance between Business and Technology. A decision maker of a company geared toward IT may consider IT Strategy more relevant than Business Strategy.

The Case Study presented in this paper evaluated the use of the ANP as a DSS that could include these options of each decision maker. The evidence found during the application of the models as a research tool in the Case Studies allows us to consider that the ANP – in the cases studied as well as in the case presented herein – may enable the results necessary for appropriate decision making.

### 5.1. Research limitations and recommendations

The research was not aimed at evaluating DSS, but rather to assess whether one such system (in this case, ANP) could include the alignment between Business and Information Technology. In this research, the selection criteria were defined only for the domains of Information Technology, leaving the definition of criteria for Business domains for future research efforts. The results presented herein are typical of the company (case) studied, therefore they cannot be generalized. However, such results may

have value for companies and managers going through the stage of procurement/selection of Enterprise Resource Planning systems.

Therefore we recommended that this research be continued, using a larger number of cases, with (or even by means of) the use of the criteria for Business domains. Another possibility would be to develop quantitative studies that seek to measure the validity of the evaluation criteria rated by the experts.

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