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A MULTICRITERIA DECISION MODEL FOR THE SELECTION OF AN INFORMATION SYSTEM FOR A LOGISTICS COMPANY USING MMASSI/IT

Abstract: *The aim of this work is to apply a methodology of decision support based on a multi-criteria decision analyses (MCDA), model that allows the evaluation and selection of an information system in a Logistics context. We carried out a literature review on supply chain management, logistics and decision theory to support all the practical work. A multi-criteria methodology for decision making support – Multi-criteria Methodology for the Assessment and Selection of Information Systems / Information Technologies (MMASSI / IT) based on logistics processes was applied during the MCDA, supported by a computer application. The ranking of the information systems best suited the decisional context was obtained and its sensitivity and robustness analyses performed.*

Keywords: *Supply Chain Management; Logistics; Information Systems; Decision-making Process; Multi-criteria Methodology for Decision Making Support.*

1. Introduction

A company's activity is by nature an open and interactive system supported by a network of articulated processes, where existing channels of communication within the company and between the company and its environment are irrigated by information (Braga, 2007).

Information Systems Management is clearly one of the major challenges companies are, currently, faced with due to achieve higher levels of individual and collective productivity.

Today's society is experiencing a moment of complete overhaul in the way companies compete. Globalization has transformed and continues to transform the way they do business. Even the primary and secondary sectors are competing strongly with a market that is no longer just a region, a country or a continent.

Differentiation, constant innovation, demand for value-added service and customer experience are key factors in the ability to ensure the viability and sustainability of business enterprises.

Systems and Technologies of Information tailored to the needs of the companies have an active role in creating the conditions necessary for businesses to become much stronger and more competitive.

In this sense, the aim of this work is to select the most appropriate software to a logistics system ensuring high levels of efficiency and effectiveness that is able to maintain and compete on equal terms anywhere in the world.

Information technology (IT) has evolved a lot in recent years and is increasingly present in the day-to-day lives. Businesses have also been affected by these developments. The

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Information Systems (IS) have the power to change the way businesses work, making the most prepared organizations to operate in a competitive market. Every day brings new applications and solutions that organizations can use to improve their efficiency and productivity.

This paper proposes, a selection model of IS / IT using the MMASSI, a multi-criteria computer application, for a service company for selecting an IS to support the logistics operation.

The aim was to evaluate different information systems available on the market and carry out the respective evaluation using Multi-Criteria Methodology to Support Selection of IS / IT.

This way it will be possible to improve the organization's processes and improve customer service.

The paper is organized as follows. Section 1 introduces information management, logistics and multi-criteria methodology. Section 2 describes the various methods of MCDA and software applications associated. Section 3 compares MCDA methodologies by pointing out their advantages and disadvantages, which are then used to choose the methodology to be used. Section 4, is provides a detailed description of the application of the method to the decision-making problem. Section 5 presents a process and a problem description. Section 6, describes an application of the methodology of analysis, characterization of the decision makers, Evaluation Criteria, Assignment of Weights to Criteria, Definition of Levels of Attractiveness, Aggregation of the valuation of alternatives for each criterion, Presentation of results, Sensitivity and Robustness Analysis. Section 7 presents conclusions.

2. MCDA

MCDA is a problem-solving methodology that organizes and synthesizes the information regarding a given decision problem in a way that provides the Decision Maker (DM) with a coherent overall view of the problem. MCDA methods assist decision making in the process of identifying the most preferred action(s), from a set of possible alternative actions (explicitly or implicitly defined), when there are multiple, complex, incommensurable and often conflicting objectives (e.g., maximize quality and minimize costs), measured in terms of different evaluation criteria (Oliveira et al., 2018). The alternative actions distinguish themselves by the extent to which they achieve the objectives, since usually none of the alternatives has the best performance for all objectives (Dodgson et al., 2000).

2.1. MCDA Methods

Different types of decision models have been used in the management of Supply Chains to inform decision making. Generally, these models can be grouped into two broad categories: 1) deterministic models, which do not consider any kind of uncertainty; 2) stochastic models, in which uncertainty is expected and considered and influences the final value of the decision variables. However, when analysing the supply chain there are some models that deal with both deterministic and stochastic aspects and hence should be treated as hybrid models, as is the case of inventory management models and simulation models (Min & Zhou, 2002).

Summarizing models of Supply Chains can be classified into three broad categories: stochastic, fuzzy, and deterministic. The models can also be translated into computer applications, see Table 1 (Appendix).

3. Construction of the Model

For accessibility to software and adaptation to the case study, three software applications were selected from which was done an analysis of advantages and disadvantages drawn up as shown in Table 2.

To build the model to apply to the case study, it was decided to choose the MMASSI / IT methodology, as this application differs from

other multi-criteria software by:

- Presents a predefined set of criteria that will characterize the IS, with suggestions from both, description of the criterion and how to measure it, for a common understanding by DM. However, the definitions and proposed metrics must be validated in terms of its consistency and coherency regarding with the multi-criteria decision problem to be applied to. The predefined criteria can be changed or removed and new criterion can still add;
- Use of a continuous scale with seven semantic levels, so it is not necessary to standardize the values. The scale range is defined by the DM considering the context of the problem;
- Easy to use and low effort in understanding it, which removes the requirement of the existence of a facilitator.

Table 1. Advantages and Disadvantages of MCDA models

	Advantages	**Disadvantages**
AHP	- Systematic and comprehensive methodology (Islam et al., 2006); - Smooth operation with subjective criteria (Islam et al., 2006); - Comparison peer-to-peer leads to more reliable results (Islam et al., 2006); - Ability to incorporate criteria with heterogeneous units (Islam et al., 2006); - Regarding MMASSI, seems to be more advantageous in the structuring of the problem and encouraging reflection of decision-makers about its details (Oliveira et al., 2014).	- In cases with many alternatives requires a prohibitive number of comparisons (Oliveira et al., 2014 and Taylor et al., 1998); - Lack of formal treatment of risk; (Taylor et al., 1998) - Use of eigenvectors in the estimation of relative weights; (Taylor et al., 1998) - Inversion of ranking when choices are added to the list of assessment (Taylor et al., 1998).
PROMETHEE	- Incorporation of group decision through the existence of scenarios; - Possibility of considering several criteria and a large number of alternatives; - Possibility of integration of incomplete assessments for some alternative / criterion by missing values.	- A range of qualitative data presents less than that used by MMASSI detail.
MMASSI/TI	- Existence of a set of pre-defined criteria covering the decisional context, being the starting point for decision-makers to define coherent and consistent family of criteria (Pereira, 2003; Pereira & Fontes, 2012); - Does not require the presence of an analyst / facilitator to be a user-friendly software, especially during the allocation of preferences (Pereira & Fontes, 2012); - There is no need to normalize the values because it uses a continuous scale with two levels of reference; (Oliveira et al., 2014) - Less cumbersome process for the decision maker (Oliveira et al, 2014.).	- Possibility to put only a final evaluation of each alternative with respect to each criterion.

4. MMASSI/TI

The MMASSI / IT is a decision support software that aims to support decision making in the selection of IS / IT with several alternatives, applied in complex contexts, considering conflicting goals. (Pereira, 2003). The choice of an IS / IT takes into account multi-criteria or attributes of different nature, which define a "good" or "bad" alternative and where no alternative, in particular, is better in all criteria; otherwise, the choice would be that one. The methodology allows the selection of the "best" alternative from among several alternatives, which can be analyzed taking into account a set of attributes or criteria. The MMASSI / IT only supports the decision in the subspace of decision theory where uncertainty is not formally modeled as a probability. On the other hand, it is a software that facilitates group decision. (Pereira, 2003; Pereira & Fontes, 2012).

The MMASSI / IT should be considered a multicriteria software, which differs from other software of this type, because of the consistent and complete set of features / attributes that characterize an IS / IT are predefined. Despite this methodological feature it is a software that allows flexibility as it allows making a change to this set. It also provides suggestions for operationalization of the criteria, which can also be modified. (Pereira, 2003).

The maximum number of alternatives assessment is fifteen in the first phase and is then reduced to ten in the second phase. In this type of issue and considering the specificity of the business having more than five alternatives that fit the specific business is not usual. However, for less demanding applications this number can be higher. (Pereira, 2003).

The number of criteria and sub-criteria, despite being already defined in the IS context, is not limited. No selection, modification and addition of new criteria are allowed. (Pereira, 2003).

5. Process description

Logistics is a shared service, the activities of this department are the management of stock levels in the warehouse, the placement of orders to suppliers, the reception and expedition of materials, the management of serial equipment (new, recycled and returned), the management of payroll and invoiced materials, partners stock management, suppliers stock management, Quality of Service (QOS's) indicators management defined by the customer such as time limits for storing and packaging equipment, management of new-damaged equipment and non-conformities (Pereira & Ferreira, 2017).

5.1. Problem description

The scope of this project arose from the inability of the current IS to meet the needs of the activities listed above.

Being an IS with little compatibility with client systems, little flexibility to develop new features and limited to a growing database, the project of selecting an information system to respond to the increased volume of business, data complexity, requirements in the processing of information and process reengineering emerged.

6. Application of the Methodology of Analysis

6.1. Characterization of the Decision Makers

The decision depends on three macro factors: Operational, pertaining to the activities of logistics and repercussions in the back-office of each client; Technical, involving the intervention of computer parameterization and interconnection of relevant internal and external systems; Financial, evaluated and validated by senior management considering the strategic planning of the company and pre-defined budget aspect.

Table 2. Characterization of the Decision Makers

Role of Decision Makers	Selection Criteria
Logistics Coordinator	Operational Criteria
Coordinator of Information Systems	Technical Criteria
General manager	Financial criteria

6.2. Evaluation Criteria

DMs were asked to adapt the pre-defined criteria to the decisional context of the company with validation and customization of these criteria and sub-criteria, as register in Table 4.

The company performed an IS planning and the alternatives that fit the company requirements concerning the logistics needs are PRIMAVERA, PHC, SAP and NAV, all with a large portfolio in companies that have similar business and logistic processes.

Table 3. Criteria and Sub-criteria for Validated Decisional Context

2nd Phase			
Code	**Criteria**	**Sub criteria or Remarks**	**Operationalization**
A2	Coefficient of risk	A2.1 - financial health of the supplier; A2.2 - Technological trends.	Qualitative scale. (measures the technological innovation and risk on maturity)
A3	Cost	Number of licenses; Cost of adding module / individual module.	Value per year or contract
A4	Maintenance	Annual cost of the same; Analysis of Contract.	Ratio: maintenance cost / Base company (billing)
A8	Ability to integrate data. (redundancy versus exploitation)	Measured by the index of shared entities to total entities; Assessment of integration into customers.	Qualitative scale
A9	Training requirements	Training users; Training those responsible for process improvement.	Ratio: Quality / cost x no trainees forming
A10	Upgradeability	Need: open system.	Qualitative scale
A11	Needs development / adaptation	Measured by time / specialist; Consider predicting the evolution of the business development necessary to quantify.	Cost technician hour x number of hours x number of technical
A14	Facility communication	External (WEB; EDI, etc.); Internal (most common protocols).	Qualitative scale
A16	Portability (porting capacity of IS / IT)	Qualitatively measure the degree of integration; Standards are standards that enable portability between IS / IT different (DDE, DBC, etc.)	If the higher level previously specified value requires the same platform
A17	Language	Pre-selection of software with equivalent language to stakeholders.	Qualitative scale
A18	Implementation time	Estimate in hours given by the supplier; Downtime of employees.	No. of hours / technical

Figure 1 shows the consensus weights of each criterion obtained by the DMs, which are normalized by dividing each one by the sum of all.

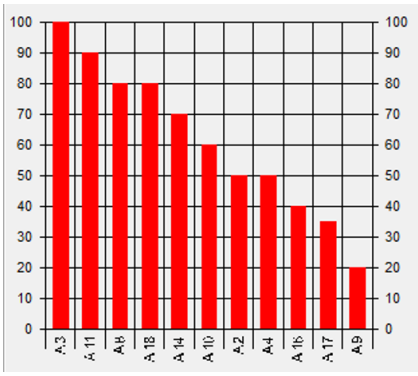

Figure 1. Assignment of Weights

6.3. Define levels of attractiveness

After the selection of the consistent family of criteria and their ranking, it is necessary to define the levels of attractiveness.

This step is related to the definition of the scale to be used in the evaluation, both for quantitative criteria and the qualitative criteria. Thus, the levels of attractiveness are MP (worse), P (worse), LP (slightly worse), N (neutral), LM (slightly better), M (better) and MM (much better).

6.4. Aggregation of the valuation of alternatives for each criterion

Finally, after performing all the above steps results are generated. The choice of decision makers along the model development process is presented in numerical form in table 5, which summarizes the results obtained by applying the additive aggregation model to the DMs elicited scores for each alternative in each criterion.

Table 4. Results of aggregation model

Criteria	A3	A11	A8	A18	A14	A10	A2	A4	A16	A17	A9	Global value
weight	0.15	0.13	0.12	0.12	0.10	0.09	0.07	0.07	0.06	0.05	0,03	1
Neutral	0	0	0	0	0	0	0	0	0	0	0	0
PRIMAVERA	50	30	-30	50	50	30	48	40	40	20	-45	30.20
PHC	40	-65	-20	40	25	45	45	30	50	10	30	16.18
SAP	-55	-60	70	-80	50	45	100	25	-40	-30	-25	-3.53
NAV	-50	-60	50	-90	30	40	78	20	-60	-40	-60	-13.63

PRIMAVERA was the IS that had best score considering the MASSI /IT methodology, followed by PHC, SAP and finally NAV IS.

6.5. Sensitivity and Robustness Analysis

Since some steps of the MCDA process can be permeated by subjectivity and uncertainty, results were validated by performing a sensitivity and robustness analysis to determine how the final ranking of alternatives changes under different criteria weighting schemes.

By the sensitivity analysis performed it is concluded that regardless of the variation rules, e.g. equal weights for criteria, increase 10% the weight of each criteria, decrease 10% the weight of each criterion, and so one. the order selection criterion remains the same.

The robustness analysis result shows the same order of alternatives that the sensitivity analysis. This result allows increased confidence in the model developed.

Thus, it can be stated that PRIMAVERA is the software that has a higher compliance with the requirements set by decision makers.

7. Conclusions

The selection of an IS represents a paradigm shift for the processes toward information control and operational excellence. Currently there is a lot of investment in this area, fostering competition among peers, since in the present economic climate businesses IT support is needed to develop automated systems that reduce waste and thereby

increase profit margins that foster their sustainable economic growth.

To satisfy the first part of the set goal, evaluate the various IS available on the market, it was described the role of information in the supply chain and more specifically in logistics, continuing with the evolution of IS in this area. Following this framework, all systems are characterized as products on the market. This characterization allowed to gather essential pre-selection of products that can be considered for implementation in the company such as functionality, compatibility, limitations, technical support and other information.

The evaluation, selection and validation of the criteria required the monitoring of the various processes involved in logistics for four months and it was performed by the three decision makers. At this stage, the IT department had a key role in the verification of technical aspects and ensuring the performance of the interface with the systems used in internal back-office and by the client operational process. For the definition and weighting of criteria, contributed the process engineering work and the Logistics Coordination and the Quality Managers.

The IS selection and choice was made using a designed multi-criteria model that was applied to the case study presented.

To obtain results of application of developed multicriteria model was selected the application MMASSI due to its affordability, flexibility and adaptation to the decisional context. After the study of the nine steps of this application, a sensitivity and robustness analysis was triggered to ensure the accuracy of the results, which direct to the implementation of PRIMAVERA because it has a more favourable cost-benefit ratio for the company. However, the implementation of this software can bring some implications for the ability to customize the evolution of the organization and the level of integration / compatibility with client software.

The aim of this work was then achieved with a market study of information systems, correct definition of valid options for pre-selection, reasoning of the applied model and presentation of the proposal to the administration with the selected software through MCDA methodology, supported in the application MMASSI.

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Appendix

Table 5. Models Translated in Computer Applications

Method	Explanation
AHP (Analytic Hierarchy Process)	The Analytic Hierarchy Process (AHP) model aims to reduce complex decisions that were considered within a certain set of simple comparisons between a set of elements belonging to the hierarchy of decision. EXPERT CHOICE tool implements AHP procedure. This method comprises the following steps: - Structuring decisions in a hierarchy; - The decision maker sets its preferences, comparing pairwise the elements from one level of the hierarchy in relation to the next higher level; - Determining the weight vector for each of the different matrices; - Determining the consistency of preferences depending on the value of consistency ratio; - Marking the relative importance of each of the alternatives in relation to the main objective (Dong et al., 2010; Chou et al., 2012; Silva 2007; Marchezetti et al., 2011).
MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique)	The MACBETH method is a model approach which requires only qualitative judgments regarding the differences in value, enabling the decision makers to quantify the relative importance of the different options. M-Macbeth tool implements this method allowing the measurement of the degree of preference of the decision maker for any one set of alternatives, thereby enabling to check the judgments inconsistencies (Montignac et al. 2009; Clivillé et al. 2007; Costa 2006).
PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation)	The approach of this method builds the degree of too much between each pair of ordered actions, taking into account the differences in scores that these same actions are a function of each attribute / alternative. This method is usually used when one wants to solve a problem that has a finite number of alternatives and different decision criteria, which will be minimized or maximized depending on the intended purpose of the decision maker (Qu et al. 2011; Vetschera & de Almeida 2012; Hu & Chen 2011). This method is divided into: - PROMETHEE I - the approach of this method is a partial pre-order of alternatives; - PROMETHEE II - the application of this method yields a complete pre-order, taking into account the flow of each of the different alternatives (Athawale & Chakraborty, 2010); - PROMETHEE III, IV, V - these methods allow a more sophisticated approach, treating particular problems with components for example.
ELECTRE (ELimination and Choice Expressing Reality)	ELECTRE method is based on relationships to determine overrun solutions, although not great it can be considered satisfactory. This approach is based on three key concepts (Wu & Chen, 2011; Wu & Chen, 2009; Bojković et al., 2010): - Concordance; - Disagreement; - Limit values. Establishing relationships used for comparison of alternatives is conducted with a range of scale.

<table>
<tr><td></td><td>This method is divided into:
<table><tr><th>Model</th><th>Type of problem</th><th>Type of criteria used</th><th>Weight used</th></tr><tr><td>I</td><td>selection</td><td>simple</td><td>yes</td></tr><tr><td>II</td><td>ordination</td><td>simple</td><td>yes</td></tr><tr><td>III</td><td>ordination</td><td>pseudo</td><td>yes</td></tr><tr><td>IV</td><td>ordination</td><td>pseudo</td><td>no</td></tr><tr><td>IS</td><td>selection</td><td>pseudo</td><td>yes</td></tr><tr><td>TRI</td><td>Rating</td><td>pseudo</td><td>yes</td></tr></table></td></tr>
<tr><td>TODIM (Discrete Multi-criteria Method Based on Prospect Theory in Uncertainty)</td><td>This method differs from others in the sense that others start from premises that choose a solution that corresponds to the maximum global of a certain value.
This method aims to evaluate multi-criteria over a base, a set of alternatives does not take into account the context in which they belong to.
TODIM method uses as a comparison pairs of criteria, which have a certain set of simple and correct resources allowing the elimination of any inconsistencies arising from the comparisons.</td></tr>
<tr><td>TOPSIS (Technique for Order Preference by Similarity to Ideal Solution)</td><td>TOPSIS allows for a quantitative treatment of a set of qualitative variables, using the similarity to the ideal solution.
In this method, the best alternative is always the one that is closer to the positive ideal solution and further away from the negative ideal solution.
It is considered as a positive ideal solution the one that maximizes the criteria considered beneficial and minimizes the criteria considered costly.
The negative ideal solution maximizes costly criteria and minimizes benefit of why not favorable or unfavorable positive/negative criteria.</td></tr>
<tr><td>MMASSI/IT (Multi-criteria Methodology for the Assessment and Selection of Information Systems / Information Technologies)</td><td>This multi-criteria method presents the decision makers with a conceptual model that allows the formation of a working basis, incorporating the knowledge of different decision makers, facilitating in this way the understanding of the problem, and allowing to systematize all information. (Pereira, 2003)
This method consists of eight distinct steps, namely:
- Defining criteria;
- Validating and describing each of the different criterion;
- Assigning weights to the criteria;
- Setting "neutral" and "best" level for each alternative;
- Defining the seven benchmarks, and required definition of ”neutral” and “better” levels;
- Defining continuous scale of seven levels;
- Evaluating the different alternatives for each criterion using the defined scale;
- Sensitivity and robustness analysis. (Pereira, 2003)</td></tr>
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