Group Decision Making for selection of an Information System in a Business Context

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Abstract

The main objective of this work is to report on the development of a multi-criteria methodology to support the assessment and selection of an Information System (IS) framework in a business context. The objective is to select a technological partner that provides the engine to be the basis for the development of a customized application for shrinkage reduction on the supply chains management. Furthermore, the proposed methodology differs from most of the ones previously proposed in the sense that 1) it provides the decision makers with a set of pre-defined criteria along with their description and suggestions on how to measure them and 2) it uses a continuous scale with two reference levels and thus no normalization of the valuations is required. The methodology here proposed is has been designed to be easy to understand and use, without a specific support of a decision making analyst.
Key words: Group decision, multi-criteria method, information systems.

1 Introduction

The development and use of Information Systems (IS) has been actively pursued by organizations for maintaining their competitive advantages in today's dynamic environment. The assessment and selection of IS applications is complex and challenging, since it often involves (a) multiple decision makers, (b) multiple selection criteria, and (c) subjective and imprecise assessments. To ensure that the best possible IS is selected with proper justification, it is desirable to use a structured approach capable of comprehensively analyzing the performance of available IS in a specific decision setting.

The group decision-making process is very difficult since it involves the presence of multiple decision-makers each of which has his/her own perception on how the problem should be addressed and on how the decision process should be guided [10]. Therefore, when multiple actors participate in a decision, it is necessary to aggregate their opinions, which can be made apriori, i.e., the group acts together as a unit, or aposteriori, i.e., aggregating the individual opinions by using some sort of priorities, see e.g. [7]. A discussion and review on these methods and their application to specific problems can be found in [11]. In here, we propose an aggregation process that although based on a group consensus, it starts by analyzing individual preferences. In our case the Decision Makers (DMs) must agree on the evaluation given to each criteria as well as on the weights that are to be associated with the criteria. However, they start by performing individual evaluations. By doing so, they have to justify to each other their opinion and thus discussion is forced.

While multi-criteria methods are well known and many different applications have been reported, apparently with exception of AHP, they are not often used in the field of IS selection due the huge number of criteria that need to be assessed and also due to teh existence of imperfect information, see [4].

they are not often used in the field of IS selection. The method, however, can be used to assess the relative attractiveness of alternative ways of accomplishing virtually any specified ends. For instance, in [14] an Enterprize Resource Planning (ERP) implementation framework has been proposed as a guide for small manufacturing enterprizes considering ERP implementation. This framework integrates simulation and can be used to better meet the goals of reducing implementation costs while increasing desired achievement levels. Multi-criteria studies in finance and accounting problems such as bankruptcy prediction, mergers and acquisitions, auditing, share repurchases can be found in [1] and the references therein. For recent surveys on multi-criteria applications see [2, 6].

Here, we propose a Multi-criteria Decision Aid (MCDA) methodology, which can be characterized as a non-linear and recursive process to select an option among several. The methodology does not aim at finding the best decision, but rather to guide the Decision Maker (DM) through the process of selecting one that best suits their goal and their understanding of the problem. Given that a solution is characterized by many different criteria, usually there is no single solution that performs better for all criteria. In addition, the existence of several DMs makes it even harder, if not impossible, to find a solution which is better for all of them. Thus, tools aiding in the decision making process are needed in order to force discussion, objectivity, and quantification. However, many of the tools available to DMs are not easy to use and require the presence of an analyst to lead the process.

The methodology we propose here is simple to use and requires a small effort to understand and use it. It has been tested on a real application to single global decision regarding the selection of a IS, as reported in Section 3. The DMs were able to perform the final evaluation and to reach a decision by themselves, i.e. without an analyst. Therefore, our contributions are twofold. On the one hand, we address the IS selection problem, which has not been addressed before. On the other hand, our methodology differs from the previously proposed ones in the sense that it uses a continuous scale with seven semantic levels with two reference and thus when quantified no normalization is required. Furthermore, it provides additional help to the GDM since it provides an original set of criteria, that can refined by GDM by removing, or modifying, or adding new criteria, along with their description and suggestions on how to measure them.

The rest of the paper is organized as follows. To begin with, in Section 2 we explain the multi-criteria methodology proposed. Then, in Section 3 we present the background of the decision situation, i.e., a case study. Finally, in Section 4 some conclusions are drawn and a discussion of future work is provided.

2 MMASSITI Methodology

A group of DMs faces the problem of choosing one alternative, over all possible others. In order to do so, the DMs must first identify the set of criteria to be used in the analysis of the the alternative solutions, i.e. what will be used to measure desirability or attractiveness of the alternatives. In the methodology we propose this is done in two phases, see Figure 1. In phase 1, the DMs determine a set of requirements, all qualitative in nature, that the available IS must satisfy in order to be considered as a possible decision alternative. Therefore, at the end of phase 1, a reduced set of alternative decisions, to be analyzed further in phase 2, have been identified. However, if the set of alternatives is though to be too large, further analysis may be performed in order too reduce it. Furthermore, the first phase is also intended to help the DMs to structure the problem, since it helps them to think about the IS assessment and its alignment with the organization's strategies and existing resources. Then, in phase 2 the DMs must specify the criteria to be used to evaluate the IS alternatives, i.e. technical requirements, functionalities, reliability, costs, customization, implementation time, etc.. These criteria include both quantitative and qualitative aspects. In this phase, the DMs must also define the weights to be used to obtain a global evaluation for each alternative through aggregation. Then, before presenting the better alternative, according to the criteria chosen and the evaluations provided by the DMs, robustness and sensitivity analyses are performed.

Significant research has been produced in the

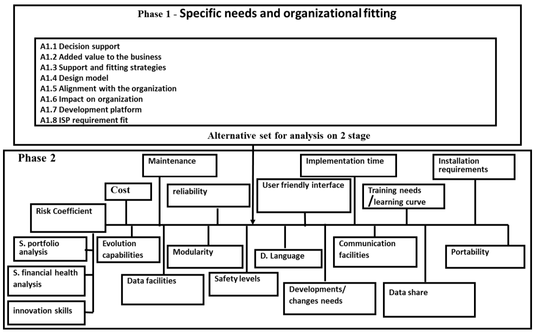

Figure 1: Structure of the proposed methodology.

multi-criteria decision area proposing several multi-criteria methodologies and applications. Some authors, such as Vincke [15], divide the methods in American aspiration and European aspiration. Regarding the American aspiration ones, the most popular and widely used are AHP - Analytic Hierarchy Process [13] and MAUT/MAUVT - Multiple Attribute Utility/Value Theory. The AHP decomposes the original problem into sub-problems that can be solved independently. Its popularity is mainly due its software support - Expert Choice-which uses pairwise comparisons along with a semantic and ratio scale to assess the DM preferences. This hierarchical model is useful in many situations; however, it is not easy to apply because of its axiomatic foundations. It assumes that there must be outer and inner independence between the different hierarchical levels and elements, which is not always easy to verify, as is the case of IS for business context. In what concerns MAUT, the most popular applications are SMART methods - simple multi-attribute ranking technique [8] and SMARTER (SMART Exploiting Ranks), an extended version due to Edwards and Barron [5]. In these cases, the different points of view are aggregated into a unique function that must subsequently be optimized. UTA - Utility Additive Method is an indirect method of applying MAUT, through PRECALC, an interactive software [9]. Within the European methods we can find ELECTRE - ELimination Et Choix Traduisant la REalité (ELimination and Choice Expressing REality) [12] and PROMETHEE - Preference Ranking Organization METHod for Enrichment Evaluation [3]. The former comprises two main parts: the construction, which compares each pair of actions and the exploitation, which provides recommendations based on the results previously obtained. Many applications are reported in chapter 5 of [6]. PROMETHEE, which is also based on pairwise comparisons (as is the case of ELECTRE) has successfully been used in many decision making contexts worldwide, for a non-exhaustive list see [2].

MMASSITI is a multi-criteria methodology for assessing and selecting information system and it has been designed to be easy to understand and use, without a specific support of a decision making analyst, to offer the Group of DMs (GDM) an effective support decision-making process, and to act as enhancer of the specification accuracy. The methodology intends to be simple so that the GDM can be lead through it considering the following steps:

Step 1: Define the consistent and coherent family of criteria in consensus;

Step 2: Analyze and validate the description of each criterion and define how to measure it;

Step 3: Define the requirements and requirement levels for the reference levels "neutral" and "better" (these requirements may be adjusted later, when evaluating alternatives);

Step 4: Establish the relative importance weights to be associated to each criterion;

Step 5: Find out the largest value for the seven semantic levels. (S_3^-: Much Worst, S_2^-: Worst, S_1^-: Slightly Worst, S_0: Neutral, S_1^+: Slightly Better, S_2^+: Better and S_3^+: Much Better).

Step 6: Assess each alternative on each criterion and assign a collective value in accordance with the range defined in step5.

Step 7: Compute the aggregated global score for each alternative, using the additive model

Step 8: Sensitivity and robustness analyses;

2.1 Defining and evaluating criterion

In our methodology, the GDM is presented with a set of pre-defined criteria that does not address a specific IS, but rather generally covers all the criteria, taking into account the choice of any IS in an organizational context. The intention is to present to the GDM a "starting point". Nevertheless, it is the GDM that defines and validates the consistent and coherent family of criteria by restricting, or modifying, or adding new criteria to initial family of criteria they were presented with.

Our multi-criteria methodology uses a continuous scale, rather than the usually used discrete scale, with seven semantic levels. For each of these levels the GDM finds a maximum numerical value within $[-100, 100]$, except for "Neutral" that is valued as 0 (S_{-3}: Much Worst, S_{-2}: Worst, S_{-3}: Slightly Worst, S_0: Neutral, S_{+1}: Slightly Better, S_{+2}: Better, and S_{+3}: Much Better). Then, an interval of possible evaluations or each semantic level is computed by using the following relation $S_{j-1} <= S_j <= S_{j+1}$. It should be noticed that no scale values is required. The range of values for each of the semantic levels remains the same throughout the whole decision making process (regardless of the criterion or of the alternative under evaluation).

Each DM decides, individually and independently, on which value of the semantic scale to put each criterion for each alternative. Then, a discussion follows among the DMs in order to find a consensus final scale (for each criterion and each alternative). Then, for each criterion and each alternative the decision makers, individually, provide a range of values within the range previously defined for the semantic scale. With these ranges a common range is found and the DMs are provided with it as well as with its median value. The GDM must then find a consensus value x_i^a for each criterion on each each alternative, which may or may not be the suggested one (the median), however it has to fall in the common range.

2.2 Computing weights and the aggregated global value

The swing weight procedure [17] is used for finding out the weight value v_i for each criterion. These values must be obtained by a consensus amongst the GDM. The collective relative value of each criterion is defined in relation to the most important one, which has a value of 100. Once all weights have been found, their value is normalized using the Weber and Borcherding formulae [16]:

$$w_i = \frac{v_i}{v}, \text{ where } \sum_i v_i.$$

The aggregated value of each alternative $x(a)$, is obtained by aggregating the utility value of each alternative on each criterion x_i^a. In order to do so, we use the additive model due to its simplicity and transparency (to the GDM).

$$x(a) = \sum_i w_i x_i^a.$$

2.3 Sensitivity and robustness analyses

Sensitive and robustness analyses are important to assure GDM confidence on the methodology results. In the sensitive analysis we evaluate the impact of the variation of the weight of a criterion using the full range of the scale. For this specific work we propose to recompute the aggregated values for all alternatives considering the following 6 scenarios.

1. the weights in the second phase are all considered equal, while in the first phase their value remains unchanged;

2. the weights have all the same value in both phases;

3. vary the value of one criterion at a the time in their full range;

4. vary the value of the two most important criteria at the same time, while the rest remain unchanged;

5. vary the value of the three most important criteria at the same time, while the rest remain unchanged.

Regarding the robustness analysis, each criterion value is varied, one at the time. Several values for the weights are considered and the range of the variation is bounded, since the criteria relative order cannot be affected.

3 Case Study

The methodology was tested on a retail software company. The company wishes to select a technological partner to supply an engine that will be used as a basis for the development of a customized application for shrinkage reduction on the supply chains management.

In a first stage, meetings were held in order to introduce and explain the methodology to the project management team, which was composed of the: Shrinkage reduction business expert; OnLine Analytical Processing IT expert; Data warehousing expert; Decision Support systems expert; Product manager.

To perform the first phase of the methodology, business and technical requirements were specified and readjusted by the GDM, based on the suggested family of criteria, see Table 1. The family of criteria proposed to the GDM was reached by performing theoretical search, based on the literature, and empirical work, questionnaires have been sent to 300 companies and interviews have been conducted with 14 companies. Several meetings were held before a finally set of criteria has been agreed upon.

Having defined the requirements that the available IS must satisfy to be an alternative, a market search was conducted. Five alternative IS were found to be of interest and thus their merits are to be analyzed. The alternatives in analysis will be referred to in this paper as A, B, C, D and E.

Using the same methodology of phase 1, in phase 2 we have reached the criteria given in Table 2. These are the criteria on which each alternative IS is going to be evaluated.

The next stage, involved setting up the relative importance ranking (weight) assigned to each criterion according to the swing weight procedure [17]. Once this was achieved, the normalized criterion weights were computed, as in Section 2.2. Next, it follows the evaluation of each alternative on each criterion. In order to do so, and as explained before in Section 2.1 a fixed scale with seven levels was used, two of which are reference values.

The company though that a full evaluation of the 5 alternatives would be a very costly process. Therefore, an evaluation using the criteria of phase 1 was performed in order to find out the which were the best alternative, that should be chosen for further evaluation. The weighted additive aggregation, see Table 3, shows that the alternatives A and B both scored 48.22, while the remaining alternatives all have similar scores and scored a little less than alternatives A and B. (C scored 44.55, D scored 44.02, and E scored 42.36), all with very similar scores.

The methodological procedure in phase 2 is similar to that of phase 1, but now considering phase 2 criteria, as given in Table 2. In addition, the global score of phase 1 is used in phase 2, since the global aggregated value of each alternative on the A1 criterion automatically goes to phase 2. As already said, the GDMs have decided that only the two best alternatives are to be analyzed in phase 2. The consensus evaluation obtained is given in Table 4.

As it can be seen in Table 4, alternative A has the best score, with a aggregated global value of 49.45, while alternative by B has a aggregated global value of 47.15. These values are quite similar, which was not a surprise since the alternatives have similar functionalities. Nevertheless, sensitivity and robustness analyses were carried out with several sets of scenarios, as explained in Section 2.3, and the order has always remained the same.

It should be noticed that, the results are only valid for this analysis scope, this company and this GDMs.

4 Conclusions

The methodology here proposed had as a main objective to be able to be used by decision makers without the presence of experts in multi-criteria decision methodologies. This was achieved since the project management team was able to apply the methodology themselves after meetings were held in order to introduce and explain them the methodology.

Another important issue, in what concerns practical utilization, is the pre-defined set of criteria that the GDM are provided with. This set of criteria was proposed after performing theoretical search, based on the literature, and empirical work, based on questionnaires and interviews. A description of the criteria and guidelines on how to quantify them are also provided. In addition, the proposed methodology has the advantage of not

A.1 Needs of the organization	Results
A1.1 Entrance cost	Aggregated expected value
A1.2 Business added value	Set of alternatives
A1.3 Support/fit company strategies	
A1.4 Platform development	
A1.5 Requirements fit	

Table 1: Criteria used in phase 1, resulting from the company business and strategic plan.

requiring normalization, regarding criteria evaluation, since it uses a continuous scale with two reference levels.

The sensitivity and robustness analyses have shown the methodology to be reliable since the recommendations have remained the same under several different scenarios.

Furthermore, we address the IS selection problem, which has not been addressed before (except for the ERP particular case). A case study has been reported.

Currently we are working on the implementation of the methodology through a decision support system. This will make the methodology even easier to use since all data will be introduced through an user-friendly graphical interface.

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A2: Vendor Risk Coefficient - IS maturity risk - Financial risk - Costumer portfolio - Innovation skill	Results - Qualitative scale
A3: Licensing and Cost - Licensing and support cost	Results - Qualitative scale
A4: Maintenance - Annual cost - Conditions	Results - Maintenance cost/year
A5: IS perceived reliability - Supplier customer portfolio - System demonstration - IS portfolio - IS life cycle	Results - Qualitative scale
A6: User friendly interface - Excel look and feel	Results - Qualitative scale
A7: Training Needs - Training quality - Training cost	Results - Training quality - technical staff no. and time
A8: Modularity facilities - Types of modularity	Results - Qualitative scale
A9: Evolution capabilities - Open systems -Future developments	Results - Qualitative scale
A10: Development Complexity -Learning curve - Development language	Results - Hours/technical staff times hour cost
A11: Safety levels - Customized - Transition position follow-up	Results - Qualitative scale
A12: Communication features - (WEB; EDI, CIM, CRM, etc.) - Standard protocols	Results - Qualitative scale
A13: Data share - Shared entities - Managing high volume/detailed data	Results - Qualitative scale
A14: Product stability/Support	Results - Qualitative scale
A15: Deployment/Implementation Cost - Estimation schedule - Additional Human Recourses (HR) - Additional IS	Results - Number of hours - HR cost -IS cost

Table 2: Criteria used in phase 2, for evaluating the IS alternatives.

	Criteria A1						
	1.1	1.2	1.3	1.4	1.5	value	
Swing	75	100	70	60	95	255	Global
Weight	0.188	0.25	0.175	0.15	0.238	1	Scale (1–100)
A	-15	0	0	-5	0	-3.57	48.22
B	0	0	0	0	-15	-3.57	48.22
C	-50	0	0	-10	0	-10.9	44.55
D	-15	-5	0	-5	-30	-11.96	44.02
E	-75	0	0	0	-5	-15.29	42.36

Table 3: Evaluation of the criteria in phase 1 and the aggregated global value.

Phase 2 criteria	Swing	Weight	IS Alternatives A	B
A1	95	0,081	-3,57	-3,57
A2	80	0,068	0	0
A3	95	0,081	10	0
A4	80	0,068	0	-15
A5	80	0,068	-10	10
A6	100	0,085	0	-15
A7	95	0,081	-15	0
A8	70	0,060	0	0
A9	70	0,060	-10	0
A10	80	0,068	0	-30
A11	50	0,043	0	0
A12	50	0,043	0	0
A13	90	0,077	0	0
A14	70	0,060	-15	0
A15	70	0,060	30	-30
Global value	1175	1	-1.1 (49.45)	-5.7 (47.15)

Table 4: Evaluation of the criteria in phase 2 and the aggregated global value.

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