Group Preference Aggregation based on ELECTRE Methods for ERP System Selection

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Abstract. The ability of enterprise information systems, such as enterprise resource planning (ERP), manufacturing executive systems (MES) and customer relation management (CRM), to improve production and business performance are demanding more attention from enterprises, since increase in competitive advantages is a goal to be reached. Integration of all the information flowing through a company is a key characteristic of ERP systems. Enterprise systems are not developed in-house and so, in order to implement an ERP project successfully, organizations must purchase ERP systems which can be aligned with their needs. In a group decision context where all opinions and preferences must be taken into account, choosing the most suitable alternative may be a hard work. In this study, a group preference aggregation approach based on a combination of ELECTRE II and ELECTRE IV method is presented within the context of ERP project selection.

Key words: Group preferences, multicriteria decision aid, ELECTRE II, ELECTRE IV, ERP selection.

1 Introduction

It is well known that market competition transforms the way in which companies deal with their business and organizational environments. Companies are looking for tools, methodologies and operational policies that support them to reduce total costs, maximize return on investment, shorten lead times and be more responsive to customer demand [1]. An Enterprise Resource Planning (ERP) system is an Enterprise Information System (EIS) designed to improve operational efficiency and enhance organizational performance. An ERP improves operational efficiency by integrating business processes and providing better access to integrated data across the entire enterprise, while to enhance business efficacy, means that a company may review (or redesign) its business practices by using an ERP [2]. Integrating business processes means fostering a seamless integration of all the information flowing through a company, including financial and accounting; human resource information; supply chain information and customer information [3, 4].

Deciding which is the most suitable ERP solution is often a difficult task for many companies. Therefore, decide among preselected alternatives using criteria that sometimes conflict with each other, based on the enterprise′s needs, has led researchers to investigate better ways to evaluate and select ERP systems. Several studies have been conducted to identify models and methodologies to support decision makers in making technology acquisitions, including in the selection of software packages. Within the context of using a multicriteria decision making for this, some papers use analytic network process (ANP) and analytic hierarchy process (AHP) approaches [1, 5, 6] to select an ERP. For the same purpose, it is possible to find combinations of these methods with Delphi Methods and goal programming [7] and by using an artificial neural network and an ANP [8]. A combination of a quality function deployment (QFD), fuzzy linear regression and zeroone goal programming to develop a framework for an ERP system selection can be found in [9]. Fuzzy approaches [10] some of which are combined with rough set and TOPSIS methods [11] have been adopted for a selection problem. Data Envelopment Analysis (DEA) approach has also been applied to the process of selecting an ERP system [12]. Outranking methods such as ELECTRE [13] and PROMETHEE [14] are also found in the literature.

Organizations select and implement ERP systems so as to obtain a variety of tangible and intangible benefits and for strategic reasons. The evaluation process of ERP systems needs to take many criteria into account [15] which include organizational factors such as the complexity of the business; dealing with change management, cost drivers, its functional requirements, system flexibility, system scalability, and also external factors such as its relationship with supply chain partners, and the pressure of value networks may affect the ERP selection process [16]. A multicriteria decision making must consider such diversity in order to better evaluate the alternatives.

Although most studies are conducted based on a single decision maker (DM), there is a strong possibility that in several organizations, an ERP system will be selected by a group. Multicriteria group decision making involves individuals who provide their preferences for a set of alternatives with respect to a set of attributes [17]. Diverging opinions may arise since DMs have their own unique characteristics with regard to their knowledge, skills, and personality. Group decision making involves two or more decision makers who take responsibility for the choice. This study deals with how support a group of individuals to achieve a collective decision when selecting an ERP system. The methodology adopted considered that DMs act in accordance with their own interests and there is no information about their relative importance to each other [18]. Group decision making has a wide diversity of applications and has been the study focus of several research studies which is indicative of its relevance [19, 20, 21, 22].

This study sets out the methodology proposed by [18] based on a combination of ELECTRE II and ELECTRE IV methods. The most widely used method in outranking methods is ELECTRE [23]. Outranking methods are particularly suitable for decision-making through the notion of weak preference and incomparability [24].

The remainder of this paper is organized as follows. Section 2 presents the model proposed and Section 3 describes a numerical application to illustrate the applicability of the model in the context of selecting an ERP system. The final section gives the conclusions of the study.

2 Model proposed

ELECTRE is a family of multicriteria decision analysis methods and its acronym stands for ELimination Et Choix Traduisant la REalité [23]. This family seeks to obtain a set of N alternatives that outrank those which do not belong to the subset N. ELECTRE assumes that DMs are able to provide intercriteria information, which reflect the relative importance among the k objectives (criteria weights).

The model proposed assumes that the decision problem is well structured and a set A of n alternatives and a set C of k evaluation criteria are also prior defined. A decision matrix D = $[d_{ij}]_{nxk}$ can be defined for each DM, in which the element dij represents the performance evaluation of the alternative a_i in accordance with criterion C_j. Note that if m DM exists, m decision matrices (n x k) are established.

This model includes the aggregation of individual priorities and a combination of ELECTRE II and ELECTRE IV methods [18] and is organized in three steps. The first step involves ELECTRE II so as to generate individual rankings of alternatives. The outranking relation is built by using concordance and discordance indices. A concordance index *C(a,b)* represents the coalition of arguments in favor of the statement "a is at least as good as b" or in other words "a outranks b". A discordance index *D(a,b)* is used to measure the arguments that may cast some doubt upon the latter statement. These indices are used to construct two pre-orders based on a strong ($a\ S^S b$) outranking relation and a weak outranking relation ($a\ S_w\ b$). Finally strong and weak rankings are deduced to obtain the final ranking for each DM. The outranking relations (strong and weak) between two alternatives a and b are presented as follows [23]:

$$a\ S^s b \iff \begin{cases} C(a,b) \geq c^+ \\ D(a,b) \leq d^+ \\ \sum_{j:gj(a)>gj(b)} w_j > \sum_{j:gj(a)<gj(b)} w_j \end{cases} \quad (1)$$

$$a\ S_w b \iff \begin{cases} C(a,b) \geq c^- \\ D(a,b) \leq d^- \\ \sum_{j:gj(a)>gj(b)} w_j > \sum_{j:gj(a)<gj(b)} w_j \end{cases} \quad (2)$$

Where $g_j(a)$ denote the evaluation of action a on criterion g_j, for all $a \in A$ and $j \in C$. In the second step of the evaluation, all individual rankings are brought together to create a global matrix of preferences (n x m) and, the third step is for aggregating all individual preferences by using the ELECTRE IV method. According to [25], ELECTRE IV was developed so as to rank actions without introducing any weighting of the criteria. This method is suitable for the last step of the model proposed since all DMs are considered to have the same weight. Note that ELECTRE IV is used in cases in which there is a pseudo-criterion family and its main feature is the absence of a weighting related to the relative importance of the criteria.

3 Selecting an ERP system: a numerical application

In this section, a fictitious case study was drawn up using ERP characteristics found in the literature to illustrate how the proposed model can be applied to selecting an ERP system for a Brazilian airline. Air services for the transport of passengers and freight is a highly competitive market and the need for useful tools and techniques to reduce costs and improve operational efficiency seems absolutely vital if an organization is to be competitive.

This company has to deal with inefficient operational procedures and an IT/IS legacy system. In order to improve its competitiveness, senior managers have announced the launch of several projects including an ERP system and the reengineering of complex business processes with a view to enhancing the effectiveness of its operational procedures and to responding better to its customers′ demands.

Four decision makers are involved in the ERP selection process: the financial manager (DM1), the IT/IS manager (DM2), the operational manager (DM3) and the customer relation manager (DM4). These DMs are also responsible for deciding on and accepting the evaluation criteria for the selection process. An analyst should conduct the evaluations of the criteria.

ISO/IEC 9126-1 is a standard that addresses quality model definition and its use as framework for software evaluation. Therefore criteria for software projects are usually established based on this standard. However it is possible to organize criteria according to other aspects and a more complete list of criteria can be found at [6]. Table 1 presents the selected criteria for this case study. Four ERP system alternatives (A1, A2, A3 and A4) are considered for this problem. All criteria and alternatives are acceptable to all DMs.

Decision model first step: individual rankings. The first step of the model comprises defining individual preferences by obtaining a preorder from each DM. The evaluation matrix is the same for all DMs since there is no modification as to evaluating the ERP products in each criterion for each DM. The evaluation matrix is shown in Table 2 and the concordance and discordance coefficients with their corresponding parameters for each DM are presented in Table 3.

The criteria weights (inter-criteria information) of each DM are shown in Table 4.

ELECTRE II is run using the data from the above tables. Table 5 summarizes the preorders obtained for each DM after the application of the method.

Decision model second step: obtaining a matrix of global evaluation. In this step, the analyst must collect all individual rankings and compile them in a global evaluation matrix. For this matrix, DMs are considered as criteria and their rankings correspond to the evaluations of the alternatives. The higher the

Table 1. Criteria adopted for selecting an ERP system

	Criteria	Criteria group	Meaning of the criterion
C1	Completeness	Functional	This is defined as the degree to which the software satisfies the functional requirements (uses a 5-level ordinal scale)
C2	Number of simultaneous users	Functional	Number of simultaneous users that can be linked to and served by the system
C3	DBMS Standards	Portability	Breadth of database management systems that can be accessed by the software package
C4	Number of modules	Maintainability	Average size of independent code units
C5	Time behavior	Efficiency	Ability of the software package to produce results in a reasonable amount of time relative to the size of the data (in milliseconds)
C6	Length of experience	Vendor	Experience of vendor in developing software products (uses a 5-level ordinal scale)
C7	License cost	Cost	License cost of the product in terms of number of users (in monetary units)
C8	Installation and implementation Cost	Cost	Cost of installing and implementing the product (in monetary units)

Table 2. Decision matrix

	C1	C2	C3	C4	C5	C6	C7	C8
A1	4	5000	4	8	0.3	4	0.7	1.8
A2	5	3000	5	12	0.6	5	0.5	1.3
A3	3	4500	4	10	0.2	4	0.6	1.7
A4	5	4000	3	5	0.7	5	0.4	2.0

Table 3. Concordance and discordance coefficients for each DM

	c^+	c^-	d^+	d^-
DM1	0.8	0.6	0.4	0.5
DM2	0.7	0.5	0.3	0.4
DM3	0.8	0.5	0.3	0.4
DM4	0.9	0.6	0.3	0.5

Table 4. Normalized weights of each DM′s criteria

	C1	C2	C3	C4	C5	C6	C7	C8
DM1	0.175	0.175	0.082	0.221	0.043	0.117	0.093	0.094
DM2	0.081	0.101	0.086	0.333	0.005	0.081	0.188	0.125
DM3	0.102	0.004	0.005	0.200	0.136	0.149	0.370	0.034
DM4	0.035	0.035	0.198	0.167	0.056	0.232	0.211	0.066

Table 5. Table of preorders for each DM

Ranking	DM1	DM2	DM3	DM4
1^{st}	A2	A2	A2,A4	A2
2^{nd}	A3	A3	A3	A3
3^{rd}	A1	A1	A1	A1,A4
4^{th}	A4	A4		

numerical evaluation of an alternative is, the better its position in the preorder, as shown in Table 6.

Table 6. Matrix of global evaluation

	DM1	DM2	DM3	DM4
A1	2	2	2	2
A2	3	3	4	3
A3	1	1	3	1
A4	4	4	1	4

Decision model third step: obtaining a group ranking. Given that there is no intercriteria information, ELECTRE IV could be applied and the following ranking is obtained (Table 7). Note that since the evaluation of an alternative corresponds to its position, any difference between alternatives implies a strict preference. Some incomparability occurred among A1, A3 and A4. Therefore,

Table 7. Global ranking of alternatives

Ranking	Alternatives
1^{st}	A2
2^{nd}	A1, A3, A4

alternative A2 which was ranked in first place is the one selected. Actually in this numerical problem, alternative A2 is a consensual alternative since it is considered as the best option by all DMs. If two or more alternatives are ranked equal first in the ranking, the DMs must review their preferences in order to achieve a group final recommendation for only one of them.

4 Final remarks and conclusions

ERP Systems have an extremely important role in helping organizations to realize their corporative strategic planning goals. Companies are looking for tools, methodologies and operational policies that support them to reduce total costs, maximize return on investment, shorten lead times and which will help them be more responsive to customers demands. However, during the ERP selection and implementation process they may well also incur high costs and face potential high risks.

This study presents an approach to support a group of decision makers to select an ERP system for a Brazilian airline. The model proposed combines two ELECTRE methods (ELECTRE II and ELECTRE IV). ELECTRE II was used to provide individual rankings of alternatives and ELECTRE IV to generate a global ranking using an approach that aggregates individual priorities.

An important observation to be made is that different results could appear if in the last step of the model proposed, the ELECTRE IV method should be changed to another other method such as the Borda Count or Condorcet. This modification is possible since it is not necessary to evaluate weights given by DMs. However, the analyst must consider the fact that these methods are based only on positions in the ranking (the Borda Count is a positional voting method while Condorcet performs a pairwise comparison of alternatives to identify the preference of the majority of the DMs) and consequently provides less information to the selection process.

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