A FRAMEWORK FOR ERP EVALUATION AND SELECTION USING MACBETH TECHNIQUE

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Abstract: Purchasing an inappropriate Enterprise Resource Planning (ERP) system may prove to be a major reason for its implementation failure. Recently, given the cost of the investment required to acquire, implement and operate an ERP system, the interest expressed by academics and practitioners concerning the selection of measures and evaluation techniques of enterprise systems is highly justifiable. Accordingly, system selection process is an important step in ERP adoption. This paper intends to elaborate a comprehensive framework for ERP selection and evaluation. It serves a threefold objective. First, it proposes a structured methodology in which strategic, functional, technical and managerial goals are considered in the selection decision. Second, it suggests a classification of the main criteria mentioned in the literature under four categories. Third, it presents an application of the Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) that allows the quantification of criteria's weights, the construction of utility functions related to each criterion and the evaluation of the candidate ERP solutions.

1 INTRODUCTION

Enterprise Resource Planning (ERP) systems have been considered from the very outset as a sophisticated, powerful and advanced type of software that aim at making an organisation more integrated, competitive and ideally computerized. They are comprised of a set of functional modules that coordinate the whole of the organisation's activities. Indeed, in comparison with other simple software that separately bring solutions to a relatively well defined requirements, an ERP system manages in an optimal way a large spectrum of business domains in order to automate and collaborate together the various organisational processes.

In this respect, ERP systems are mainly destined to achieve operational and strategic goals that provide an organisation with a competitive edge in an ever-changing business environment, enhance its business practices and improve its decision making processes.

During the last decade, it has been widely reported that an extensive part of ERP projects fail to deliver the initial value expected from them. The success rate is at alarmingly low level and they tend to be a very heavy burden on the organisations'

budget. Therefore, it is quick to point out that the complexity of ERP systems and the vagueness of the purchasing objectives may prove to be a barrier to their successful implementation. To tackle this issue, Wu, Tai, Tsai and Lu (2009) suggest that a great deal of importance must be attached to the selection stage of the ERP acquisition process. In this regard, purchasing alternatives should be subject to relentless questioning.

This paper intends to elaborate a comprehensive framework for ERP selection. Moreover, it provides specific advice to organisations when considering selection criteria. It serves three major objectives. First, it proposes a structured methodology in which strategic, functional, technical and managerial goals are considered in the selection decision. Second, it suggests a classification of the main criteria mentioned in the literature under four categories. Third, it presents an application of the Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) that allows the quantification of criteria's weights, the construction of scales related to each criterion and the evaluation of the different ERP options.

2 ERP SELECTION PROCESS

2.1 Selection Methodology

Selecting an optimal ERP solution is a critical factor for its successful implementation. In fact, an in-depth understanding of the underlying business benefits resulting from ERP adoption should be highly taken into account during the selection decision. In this regard, four important goals are deemed wise to be emphasized when defining the organisation's requirements: Strategic, functional, technical and operational. In this section, we propose a flowchart for selecting an ERP system (Figure 1).
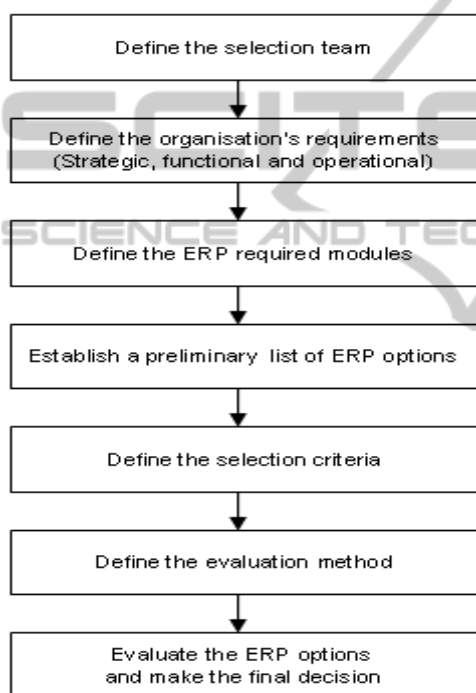

Figure 1: ERP selection's flowchart.

2.2 Selection Criteria

In the literature, many authors suggest different sets of selection criteria related to ERP package itself (Birdogan and Kemal, 2005) whereas others focus on criteria dealing with supplier's support and technical assistance (Eric, Wang, James and Gary, 2008; Remus, 2007). The list of criteria adopted differs mainly according to the organisation related business model and size. This paper suggests a classification of the main criteria found in the literature into four subcategories. The following four subcategories are:

Strategic Criteria: They assess the degree to which

the ERP system supports or constrains the ability to execute the organisation's business strategy. To this end, the ERP system should adapt to the new business and technology changes that would happen in the future. It is worth pointing out that the strategic criteria should reflect the strategic objectives that each organisation wants to attain. As examples of strategic criteria, we mention future anticipation and benefits realization.

Functional Criteria: They assess the functional coverage of the organisation's requirements. Teltumbde (2000) argues that the generic functionalities implemented in the marketplace available ERP products couldn't yet meet all the industry-specific requirements. However, with the advances in technology and the maturity reached by ERP solutions, the basic functionalities are well covered and slight differences could be made among them. Hence, the decision maker should focus more on features that really matter such as coding and nomenclature capabilities, international operation's support and transaction's history management.

Technical Criteria: They assess the technical features of an ERP solution assuming that it is basically an IT system. Examples of these criteria are: Usability, reliability, interoperability, security, maintainability and efficiency. Refer to the work of Liang and Lien (2007) for more details about these criteria. The authors used the ISO 9126 norm to define a set of quality criteria.

Managerial Criteria: They evaluate the ERP system implementation's methodology; they include the vendor's reputation and market share, the integrator's support and the adopted project management methodology (Quality management, implementation time and total cost of ownership).

2.3 Evaluation Method

Numerous methods have been applied to ERP selection. They include scoring, ranking, mathematical optimisation, and multi-criteria decision making (MCDM) (Wei, Chien and Wang, 2005). The ERP system selection is influenced by multiple factors such as decision-maker's preferences, candidate solutions, and the availability of limited resources. Hence ERP selection could be considered as a kind of MCDM problem (Wu, 2008). This paper uses MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) to direct how to determine an evaluation of different ERP solutions. MACBETH is introduced by (Bana e Costa and Vansnick , 1994) and allows the quantification of criteria's weights

together with the construction of utility functions related to the criteria. An aggregation function is then elaborated to evaluate each ERP product. The advantage of choosing MACBETH among other techniques is its ability to totally cover the decision process from the expression of the decision maker's preferences to the making of final decision. In addition, MACBETH allows the systematic construction of utility functions related to each criterion which is not widely supported by similar methods.

The remainder of this section deals with an explicit formalization of an aggregation function using MACBETH in the context of independent criteria.

2.3.1 Definition of Utility Functions

Let $C1$, $C2$, $C3$, and $C4$ be the set respectively representing the different strategic, functional, technical and managerial criteria introduced in the previous section. Let (A_i, S) be an ordered set of values representing the performances of the different ERP products on each criterion C_i with $i = 1\ldots4$. The binary relation "S" defines an order over A_i. For each ERP_W and ERP_Z that have respectively "x" and "y" as performances on A_i: $x S y$ means that the decision maker considers that ERP_W is at least more attractive than ERP_Z regarding C_i.

The purpose of the methodology is to define four marginal utility functions U_i as homomorphism functions from (A_i, S) to $(|R, \geq)$. Each utility function U_i is interpreted as a numeric scale translating the linguistic preferences of the decision maker on C_i criterion to real numbers. According to Grabisch (2005), the aggregation model has to guarantee the commensurability of utility functions to be coherent. MACBETH ensures this prerequisite by incorporating into the model two fictitious values 0_i and 1_i related to each criterion. 0_i is defined as a neutral value with respect to the criterion C_i. It is considered as 'neither satisfying nor unsatisfying' particular reference for C_i. 1_i is defined as a good value, which is more attractive to a decision maker than neutral, and is defined as undoubtedly satisfying particular reference.

Based on these two references 0_i and 1_i, we distinguish an unattractive ERP on C_i if it is less attractive than 0_i, an attractive ERP on C_i if it is more attractive than 0_i and an outstanding ERP on C_i if it is at least as attractive as 1_i.

Similarly, let ERP neutral $(0_1, 0_2, 0_3, 0_4)$ and ERP good $(1_1, 1_2, 1_3, 1_4)$ denote two fictitious ERP systems that have respectively 0_i and 1_i for the four criteria.

MACBETH is based on a questioning procedure that allows the construction of utility functions through a discussion with the decision maker. Let

$$B = A \cup \{ERP_{neutral}, ERP_{good}\}$$
A is the initial set of ERP options \hfill (1)

For each $x, y \in B$ and for each criterion C_i the decision maker is asked to verbally judge the difference of attractiveness between x and y regarding C_i. When judging, a decision maker has to choose one of the following categories: **A0**: no difference; **A1**: very weak; **A2**: weak; **A3**: moderate; **A4**: strong; **A5**: very strong; **A6**: extreme. However, if the decision maker is unsure about the difference of attractiveness between two ERP options, they may choose the union of several successive categories among these above.

Utility functions are then obtained by the means of MACBETH matrix of judgment that are called the MACBETH basic scales. The consistency of this matrix is verified during the expression of the decision maker's preferences. The M-MACBETH (http://www.m-macbeth.com/) software implements this procedure. The numerical scales are extracted thanks to linear programming. A linear transformation U_i for each criterion C_i is used to refocus the scales on the two values 0 and 1 as follows:

$$U_i \rightarrow \alpha_i U_i + \beta_i \text{ with } \alpha_i > 0 \text{ and } \beta_i \in |R$$
$$U_i(0_i) = 0 \text{ and } U_i(1_i) = 1 \text{ for each } i \in \{1,2,3,4\} \quad (2)$$

To illustrate this step, Figure 2 shows the judgement matrix related to three ERP systems according to the functional criteria. MACBETH software defines the values taken by the ERP systems in the current scale column. The same procedure must be applied to the other criteria in order to determine the other utility functions.

	Good	ERP3	Neutral	ERP1	ERP2	Current scale
Good	no	moderate	moderate	extreme	extreme	1.00
ERP3		no	weak	moderate	strong	0.29
Neutral			no	moderate	strong	0.00
ERP1				no	weak	-0.71
ERP2					no	-1.14

Figure 2: Judgments matrix related to functional criterion.

2.3.2 Aggregation Function Determination

The global attractiveness of each ERP system is defined after the determination of the different

criteria's weights. The aggregation function adopted in MACBETH is the weighted mean (WM). In this regard we have:

$$\Psi(U_1, U_2, U_3, U_4) = \sum_{i=1}^{4} V_i \, U_i \quad | \sum_{i=1}^{4} V_i = 1 \qquad (3)$$

It is easy to notice that the coefficients V_i could be determined as:

$$V_1 = \Psi(1_1, 0_2, 0_3, 0_4); V_2 = \Psi(0_1, 1_2, 0_3, 0_4)$$
$$V_3 = \Psi(0_1, 0_2, 1_3, 0_4); V_4 = \Psi(0_1, 0_2, 0_3, 1_4) \qquad (4)$$

Let denote by [Strategic], [Functional], [Operational] and [Managerial] four fictitious ERP systems having respectively the following values: $(1_1, 0_2, 0_3, 0_4)$, $(0_1, 1_2, 0_3, 0_4)$, $(0_1, 0_2, 1_3, 0_4)$ and $(0_1, 0_2, 0_3, 1_4)$.

By using categories **A0 - A6** to judge the difference of attractiveness between each two fictitious ERP systems (Figure 3); we obtain a MACBETH scale which measures the overall attractiveness of the above fictitious ERP systems. The values obtained represent the weights attributed to the four criteria (Figure 4).

	[Functional]	[Technical]	[Operational]	[Strategic]	[neutral]	Current scale
[Functional]	no	v. strong	v. strong	vstrg-extr	extreme	44.44
[Technical]		no	moderate	moderate	v. strong	24.07
[Operational]			no	moderate	strong	18.52
[Strategic]				no	strong	12.97
[neutral]					no	0.00

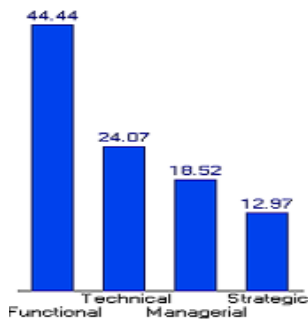Figure 3: Judgement matrix for weight's determination.

Figure 4: Criteria's weights.

3 CONCLUSIONS

This paper deals with the selection process of an ERP system. A stepwise methodology is proposed along with a set of criteria in order to support the purchasing organisation in its initial selection stage.

This methodology addresses the evaluation and selection of ERP products according to four major categories of criteria. Besides, MACBETH is used to quantify the attractiveness and repulsiveness of the different ERP options. Hence, this paper provides a comprehensive framework that represents a useful means for organisations to evaluate and select an ERP system.

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