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ERP software quality assessment using fuzzy VIKOR

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A B S T R A C T

Enterprise Resource Planning System is an important investment for organizations and determines future competitiveness and performance of a firm, which could be substantially effective. The primary objective of enterprise resource planning systems is to consolidate operational procedures among various departments, management information systems and resource allocation of the companies. Given the fact that the selection process for enterprise resource planning system is a multi-criteria decision problem and there are some ambiguities with various criteria, the use of fuzzy logic is inevitable, therefore, in this study, the main indices and standardized evaluation software enterprise resource planning system identification were used to rank six software packages including Oracle, SAP, SSA Global Solution, Sage Group, Microsoft Business Solution, People Soft focus. The results indicate that the highest priority is associated with the SAP software.

1. Introduction

During the past few years, the recent advances on information and communication technology have significantly influenced most organizations. The environment is becoming complex and all organizations need appropriate distribution of goods and services for multi-task information for timely and effective decision-making and management of human resources (Berchet & Habchi, 2005). Enterprise Resource Planning (ERP) is a software package, which is responsible for the integrity of the information flow throughout the organizations, including finance, accounting, organizational resources, supply chain and customer information (Behkamel et al., 2009). ERP is a customizable software information system for information and processes, which are based on information from the operational areas of the organization and gives coherence (Pabedinskaitė, 2010). ERP system package cannot respond to all businesses and processes, thus a single software package cannot respond to all functions or specialized business requirements.

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Companies have to choose a flexible ERP systems to effectively meet the customers' needs (Ehie & Madsen, 2005). Software evaluation is inherently uncertain activity to cope with the uncertainty, which arises from the perception of the human mind. This research proposes a model based on software offered fuzzy multi criteria decision making for evaluating the software (Zadeh, 1965; Büyüközkan & Ruan, 2008).

1.1. Background of research

ERP system is a substitute for traditional material requirements planning systems and manufacturing resource planning system (Kaur & Mahanti, 2008). An enterprise resource planning system is a technique for effective planning and controlling all resources required for production, sending and responding to customer requirements in manufacturing, distribution and service organizations (Mahmoudi & Ahmadi, 2008). ERP systems are regulatory and flexible information systems where information and information-based processes within organization integrate in the organization unit (Hendricks et al. 2006). ERP system is a tool for collection and integration of all knowledge and management skills for the whole organization, in a single database, from finance to human resources (Mahmoudi & Ahmadi, 2008). Many businesses believe that the ERP system can provide a strategic competitive advantage (Davenport, 1998). Chen and Hwang (2005) used fuzzy logic as a suitable model to choose the right system prepared for organizations.

Cantanam and Keparisis (2005) used nonlinear programming for optimal allocation of resources with interaction factors. According to Ehie and Madsen (2005), eight factors explain 86% of the variances that impact ERP implementation. Mahmoudi and Ahmadi (2008) presented a model for ERP system selection with field studies and observations on a series of criteria and classified them into three criteria for vendors, users and technical and technological criteria (technological). They also used analytic hierarchy process for evaluating proper system. Zhang (2005) used seven key success factors influencing on ERP for an organization, including vision and business plan, change management, communication management, combination, skills and wages of the implementation, support from senior management (Citied by Folhono & Delgado, 2006). Plant and Willcocks (2007) performed a literature review on 22 papers and ERP success factors in organizations and investigated the impact of these factors for the project life cycle. Pabedinskaitė (2010) established the factors of the success of ERP implementation. Table 2 summarizes the survey.

Table 1
Previous studies at a glance

Researcher	Year	Result of research
Alanbay	1988	Using the analytic hierarchy process for evaluating enterprise resource planning system
Chen Wei & Wang	2000	The use of fuzzy logic to select the appropriate system in an organization
Santhanam & Kyparisis	1995	The use of fuzzy logic to select the appropriate system in an organization
Lee & Kim	2006	The use of zero and one planner to select appropriate systems in an organization
Folhono & Delgado	2006	Determine and divide the success factors of ERP is divided into seven categories:
Plant & Vilkikos	2007	Identify and divide the key success factors of ERP 22 categories
Pabedinskaitė	2001	Identify and divide the key success factors ERP6 category

The market of ERP systems software continuously grows in the information technology (IT) industry. In recent years, because of globalization and competitive business environment, companies are forced to investigate in resources to implement ERP system (Berchet & Habchi, 2005). The process of system implementation of ERP system requires vendor and system selection, implementation of the system, change management of business processes and operational review of the system. So we all need to look for an appropriate selection criteria to specify and to implement the ERP system (Karsak & Özogul, 2009).

1.2. The conceptual framework

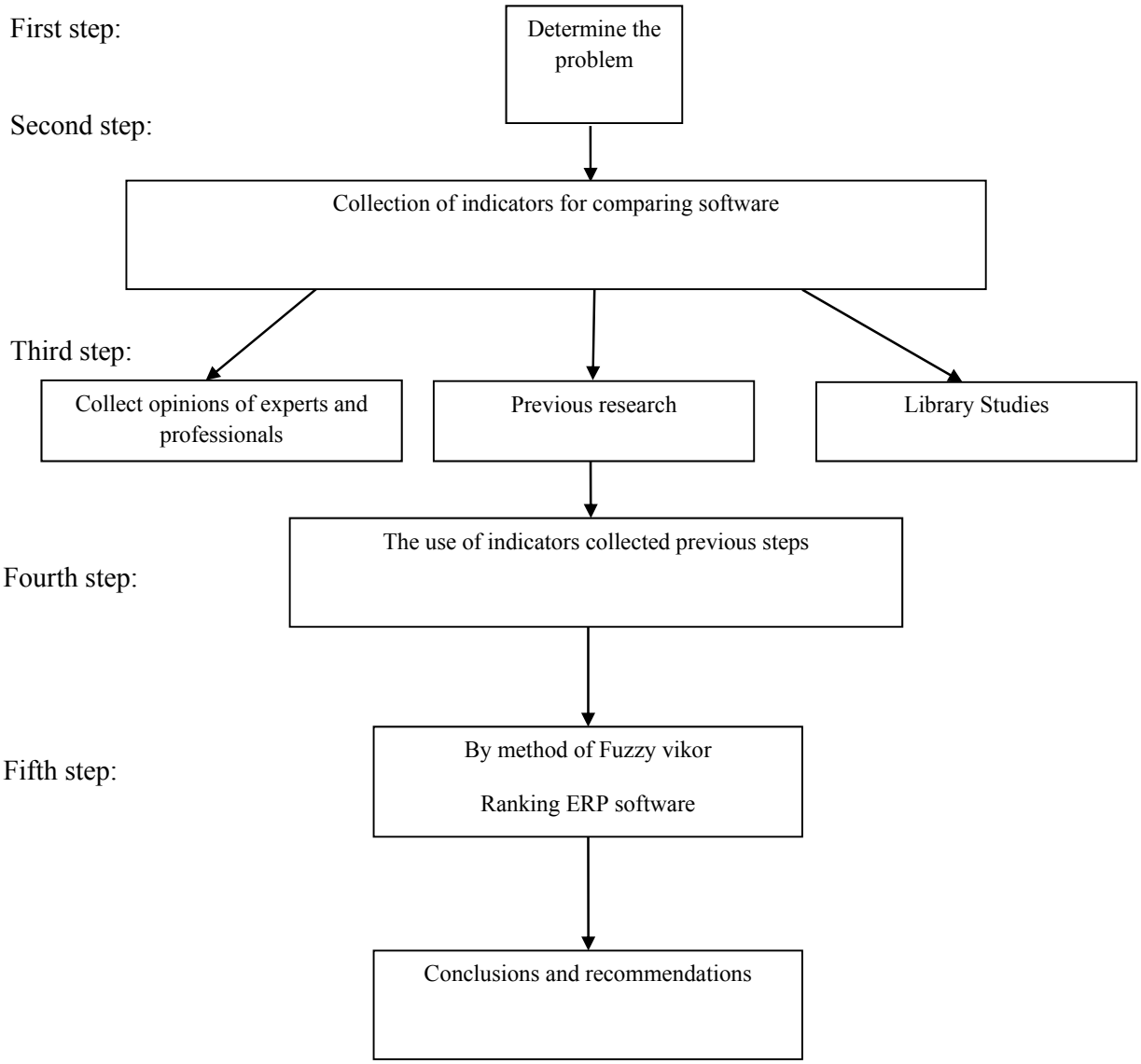

Fig. 2. The structure of the proposed model

2. Material and Method

Research methods in terms of objective are applied and in term of data collected is descriptive-survey. Data were gathered by questionnaire. The Delphi method is a method of gathering information on the questionnaires. To determine the validity of questionnaires, expert's opinion was used. Cronbach's alpha coefficient was used to determine the reliability of questionnaires because the alpha coefficient was calculated to be 0.713 reliability of questionnaire was confirmed.

It is obvious, however Cronbach's alpha index is close to 1, the internal consistency of the questions is high and so the questions will be more homogeneous. Cronbach's reliability coefficient of 45% low, 75% as moderate and acceptable, and 95% coefficient proposed high (Cronbach, 1951). Obviously, if the alpha value is low, eliminating some of the questions in the questionnaire increases the Cronbach's alpha value.

Table 2
Calculation of reliability of questionnaire (Source: authors calculations)

Cronbach's Alpha	N of Items
0.713	32

The fuzzy method is used for ranking applications as well. The implementation of Fuzzy Logic based on inaccurate data in the ERP software selection issue is important. In fact, when there is an uncertainty in human decision and the mathematical numbers cannot be converted, the results can be somewhat misleading. Therefore, fuzzy sets are used for the present study to help reduce the complexity of the decision. In this study, to describe the characteristics of software quality, 32 criteria are approved by at least three different approaches to evaluate 6 software packages including Oracle, SAP, SSA Global Solution, Sage Group, Microsoft Business Solution, People Soft and Table 2 demonstrates the results of the survey (Sarmad et al. 2005):

Table 3
Criteria for software quality

Criterion	ISO 9126	Liang & Lien, 2006	Lien & Chan, 2007	Wei et al., 2005	Percin, 2008	Total
Competence	√	√	√		√	4
Health Systems enterprise resource planning	√	√	√	√	√	5
Interoperability with other sectors	√	√	√	√	√	5
Utility enterprise resource planning system	√	√	√	√	√	5
Maturity of enterprise resource planning systems	√	√	√	√	√	5
Security of Enterprise Resource Planning Systems	√	√	√	√	√	5
Error rate	√	√			√	3
Refresh Features	√	√	√	√		4
Understandability	√	√	√		√	4
Ability to Teach	√	√	√	√	√	5
Acceptability	√	√	√	√	√	5
Performance behavior time	√	√	√	√		4
Efficiency of resource	√	√	√		√	4
Analysis Capability	√	√		√		3
change Capability	√	√	√		√	4
System stability	√	√		√		3
Testable	√	√	√	√		4
Compatibility	√	√	√		√	4
Ability to install the system	√	√	√			3
Comply with enterprise resource planning systems	√	√	√	√	√	5
Replaceable	√	√	√	√	√	5
Market share	√	√	√	√	√	5
Industrial dealer license	√	√	√			3
Service and Support	√	√	√	√	√	5
Training seller	√	√	√	√	√	5
The cost of software	√	√	√	√	√	5
Hardware costs	√	√	√	√	√	5
Annual maintenance costs	√	√	√	√	√	5
Staff training costs	√	√	√	√	√	5
Time required to re-engineer	√	√	√	√	√	5
The time required for testing and delivery	√	√	√	√	√	5

In this study, a new method for ranking fuzzy numbers was used. This method can be used for auxiliary functions. In order for a fuzzy number functions A, A_p and A_n are defined:

$$A_p(u) = \cup_{u \geq x} \ A(x) \ , \tag{1}$$

where A_p is the set of fuzzy numbers and a fuzzy number A is a triangular number $A\ (l, c, r)$ shown as follows:

$$A_p = \begin{cases} 0 \\ A(u) \\ 1 \end{cases}$$

Set *A (n)* is defined as follows:

$$A_n = \cap_{y \geq x} \ (1 - A(u)), \tag{2}$$

where A_n a set of fuzzy numbers that they are necessarily larger than *A* displayed as:

$$A_n = \begin{cases} 0 \\ 1 - A(u) \\ 1 \end{cases}$$

Ranking options is determined using the above method. In addition, all alternatives are ranked using VIKOR.

3. Results

A fuzzy number is a generalization of a regular, real number in the sense, which is not associated with one single value but rather to a connected set of possible values, where each possible value has its own weight between 0 and 1. Since the questionnaire was used for weighting indicators and ranking of ERP systems were designed based on linguistic variables, therefore, they cannot be expressed as a number. The use of linguistic variables enables respondents to have a better choice in addition; these variables can be changed by a fuzzy logic absolute numbers (Zadeh, 1965). To receive experts' view and to determine the weight of criteria for evaluating ERP systems, a questionnaire was designed and distributed among some experts. The questionnaire, in term of each question, was designed in Likert scale including five items a) very important b) important c) average Important, d) low importance, and E) unimportant and to convert the linguistic variables into relatively uncertain numbers and quantity of each item, a triangular fuzzy number was used (Dilliard & Yuthas, 2006), as shown in Fig. 1.

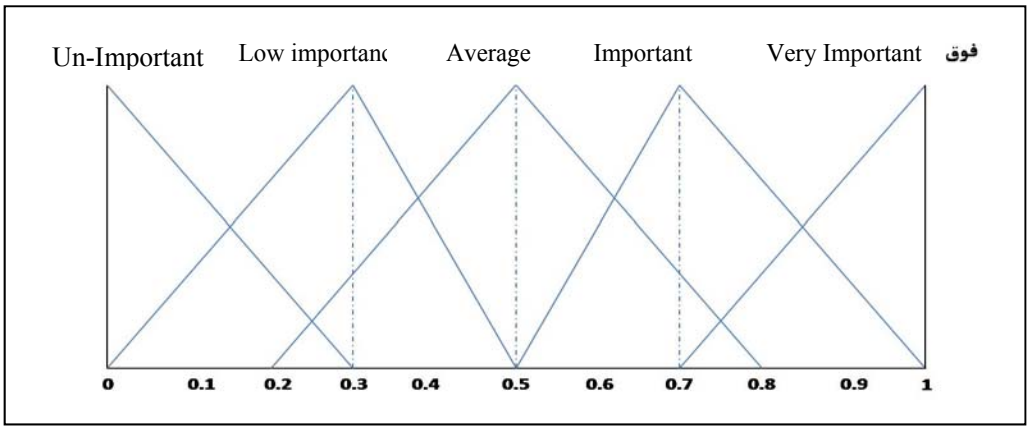

Fig. 1. displays the five triangular fuzzy numbers weighted index options

Based on the concepts of fuzzy logic and Minkowski formula to convert fuzzy numbers into crisp numbers ($\chi = m + (\beta-\alpha) / 4$) (Höhle, 1980), the fuzzy numbers are converted into crisp value shown in Table 4.

Table 4
Table of transform the triangular fuzzy numbers into crisp numbers.

Options	Number of qualitative (linguistic variable)	Triangular fuzzy number (m, α, β)	Absolute number
A	Very important	(1, 0.3, 0)	0.925
B	Important	(0.7, 0.2, 0.3)	0.725
C	Average important	(0.5, 0.3, 0.3)	0.500
D	Low importance	(0.3, 0.3, 0.2)	0.275
E	Unimportant	(0, 0, 0.3)	0.075

To prepare the decision making matrix, first the experts' opinions were combined using the geometric mean. The VIKOR multi-criteria decision making method was used for ranking. VIKOR method as an applied technique and implementation of multi criteria decision making has been presented. This method focuses on ranking and selecting from a set of options in the presence of conflicting criteria. Peaceful solution to the problem with a number of conflicting criteria can help decision maker reach a final decision. Peaceful solution created by Yozlni is a feasible solution, which ultimately leads to ideal solution. VIKOR ranking system is a peaceful and nonviolent solutions for introducing the ranking index to reach near ideal solution. The method includes the following steps: first, the best rank f_i^+ and worst rank f_i^- for all criteria.

Table 5
Analysis of experts' opinion using fuzzy Vikor (Source: authors calculations)

Options	fi^+	fi^-
SSA Global Solution	(0.76,0.96,1)	(0.18,0.38, 0.58)
Sage Group	(0.72, 0.92, 1)	(0.24, 0.44, 0.64)
Oracle	(0.48, 0.68, 0.78)	(0.3, 0.5, 0.7)
People Soft	(0.68, 0.88, 1)	(0.18, 0.38, 0.58)
Microsoft Business Solution	(0.72, 0.92, 1)	(0.12, 0.32, 0.52)
SAP	(0.54, 0.74, 0.94)	(0.06, 0.26, 0.46)

And S_j then R_j are calculated as follows,

$$S_j = \sum_{i=1}^{n} wi \frac{(fi^+ - f_{ij})}{(fi^+ - fi^-)} \qquad S_{\mathrm{j}} \in [0,1] \tag{3}$$

Table 6
Analysis of experts' opinion using fuzzy Vikor

Options	s_j
SSA Global Solution	(0.1955,0.5433,1)
Sage Group	(0.155,0.491,1)
Oracle	(0.1784,0.5213,1)
People Soft	(0.088,0.45,1)
Microsoft Business Solution	(0.1391,0.4625,1)
SAP	(0.0748,0.364,1)

$$R_j = \max\left(w_i \frac{(fi^+ - f_{ij})}{(fi^+ - fi^-)}\right) \qquad R_{\mathrm{j}} \in [0,1] \tag{4}$$

Table 7
Analysis of experts' opinion using fuzzy Vikor

Options	R_j
SSA Global Solution	(0.3168,0.6392,0.88)
Sage Group	(0.2772,0.5882,0.82)
Oracle	(0.2772,0.5882,0.82)
People Soft	(0.2772,0.5882,0.82)
Microsoft Business Solution	(0.3132,0.6068,0.94)
SAP	(0.1056,0.34,0.6864)

In the next step, Q_{j} values are calculated as follows,

$$Q_j = \frac{v(S_j - S^+)}{(S^- - S^+)} + \frac{(1-v)(R_j - R^+)}{(R^- - R^+)}, \tag{5}$$

where v is decision making strategies weight or the maximum utility of group. Next, we propose a peaceful solution (Cantanam & Keparisis, 2005). Finally, we prioritize software of enterprise resource planning systems given in Table 8.

Table 8
Final ranking software of enterprise resource planning system

Options	Q_j	Rank
SAP	(0.0902,0.352,0.8432)	1
People Soft	(0.1826,0.5164,0.91)	2
Oracle	(0.226,0.55205,0.91)	5
Sage Group	(0.2161,0.5369,0.91)	3
Microsoft Business Solution	(0.22615,0.53465,0.97)	4
SSA Global Solution	(0.25615,0.59125,0.94)	6

4. Discussion and conclusion

Now, we are at time known as the information age. If the information is timely, accurate and fast to reach managers, they can help make quick decisions and promote organization's agility. This agility helps organization react quickly to environmental changes and finally increases the threat of competitive rivals and resources and adapts to customer's needs. All of this is possible without the use of software solutions. Best known enterprise software solutions in recent times are called enterprise resource planning systems. However, as the cost of buying and deploying these solutions is extremely high and in the case of non-compliance with the organization, the organizations impose very large expenses and selection criteria should be the solutions.

The purpose of this research was to help organizations, both governmental and nongovernmental organizations to choose the best option to buy and to implement software solutions in the ERP systems. The research was a framework in association with effective solution of assessment problem of software solutions that offered through Multi Criteria Fuzzy method. VIKOR approach helps decision-makers achieve a peaceful solution to the maximum group utility for the maximum and minimum regret and importance weights of criteria and alternatives were analyzed by triangular fuzzy numbers. Using this method, the uncertainty associated with the assessment and evaluation process was conducted, effectively. In selecting a software solution for enterprise resource planning systems ISO evaluation criteria were applied which in turn could improve the evaluation process.

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