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Business intelligence evaluation model in enterprise systems using fuzzy PROMETHEE

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ABSTRACT In this paper, a new model to evaluate business intelligence (BI) for enterprise systems is presented. Evaluation of BI before making decisions about buying and deployment can be an important decision support system for managers in organizations. In this paper, a simple and practical method is presented that evaluates BI for enterprise systems. In this way, after reviewing different papers in the literature, 34 criteria for BI specifications are determined, and then by applying fuzzy PROMETHEE, different enterprise systems are ranked. To continue to assess the proposed model and as a case study, five enterprise systems were selected and ranked using the proposed model. The advantages of PROMETHEE over other multi-criteria decision making methods and the use of fuzzy theory to deal with uncertainty in decision making is assessed and it is found that the proposed model can be a useful and applied method to help managers make decisions in organizations.

KEYWORDS Business intelligence, enterprise systems, Fuzzy PROMETHEE, fuzzy theory, PROMETHEE

1. INTRODUCTION

Traditional industrial informatics focus on how to provide more efficient and productive operations. But nowadays they cannot stay competitive just by providing more efficient and productive operations. They are facing the challenge of processing huge amounts of data and turning it into smart and timely decisions to deliver better products and services (Lian & Li 2012). In the present competitive world, accurate and up-to-date knowledge and information is considered to be a crucial factor for all organizations. In fact, today organizations need knowledge and information to achieve a competitive advantage when making important decisions. IT development in recent decades has led to the appearance of different enterprise information systems such as enterprise resources planning (ERP), supply chain management (SCM) and customer relationship management (CRM), which are introduced as modern tools in important enterprise decision-makings by storing different data in themselves (Alter 2004; Power 2008). Enterprise information systems or enterprise systems can be defined as follows: software systems for business management, encompassing modules supporting enterprise functional areas such as planning, manufacturing, sales, marketing, distribution, accounting, finance, human resources management, project management, inventory management, service and maintenance, transportation and e-business (Rashid et al. 2002).

In order to deliver useful information for decision-making, business intelligence (BI) is a key technology (Moss & Atre 2003). BI software is among the many software products that organizations utilize to ensure their place in the market (Abzaltynova & Williams 2013).

Most companies today use a set of different BI tools, instead of focusing only on one. The reason for this may be that different users prefer different types of BI tools (Sabanovic & Søilen 2012). The concept of BI was first introduced by the Gartner group and in general it refers to tools and technologies such as data storing, reporting and analyzing information. In the past, researchers dealt with presenting tools for evaluating BI in enterprise systems. But in most studies, BI was examined and analyzed as an independent tool from enterprise systems. Until 2006 and before Lönnqvist & Pirttimäki's study, the existing studies in the field of BI tried to explain and prove the need for investment and the value of BI. Lönnqvist & Pirttimäki (2006) for the first time introduced a set of criteria for examining the performance of BI. Albashir et al. (2008) investigated the effect of BI systems on business procedures and presented a method to measure the effect. In 2009, Lin et al. established a performance assessment model based on analytic network process (ANP) for an independent system (Lin et al. 2009). Nyblom et al. (2012) proposed a simple model for evaluating the performance of BI software systems based on what companies find to be most important; efficiency, user friendliness, overall satisfaction, price and adaptability. Fourati-Jamoussi & Niamba (2016) proposed an evaluation model for BI tools using cluster analysis. Ghazanfari et al.'s study in 2011 can be regarded as the first study to investigate BI in enterprise systems in which the authors have presented some criteria to evaluate BI in enterprise systems by examining different studies of BI and enterprise systems (Ghazanfari et al. 2011). In 2012, Rouhani et al. presented the fuzzy TOPSIS method for evaluating BI in enterprise systems. Also, in 2015, Rouhani & Zare presented a method for evaluating BI by using a fuzzy analytic network process (F-ANP) (Rouhani & Zare 2015).

One of the actions that influences the efficiency of decisions while making them is choosing a suitable method for decision-making among the existing methods. The Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) is one of the best known decision-making methods. Compared with other methods, this method is considered to be the best and has more advantages in different factors such as the ease of use, interpretation of parameters, reliability of results, amount of interaction required by the user and ease of understanding (Al-Shemmeri et al. 1997; Gilliams, 2005; Mahmoud & Garcia, 2000). On the other hand, since the existing data on decision-making methods are usually based on opinions and the experiences of decision-makers and are expressed qualitatively, it is more likely to have errors in opinion interpretation. This has led to the suggestion of using fuzzy theory in solving problems with qualitative observations. In this paper, a model for evaluating BI in enterprise systems based on a fuzzy PROMETHEE method is presented. The rest of the paper is organized as follows: the second section of the paper deals with introducing the concept of BI and its definitions. Also in this section, the PROMETHEE method is briefly described. The third section covers the description of the steps for the fuzzy PROMETHEE method for evaluating BI in enterprise systems. Finally, the conclusion section deals with conclusions, results and suggestions.

2. THEORETICAL BASICS

2.1 Business intelligence

Business intelligence can bring critical capabilities to an organization, but the implementation of such capabilities is often problematic (Adamala & Cidrin 2011). BI was first defined by Howard Dresner, a researcher of the Gartner group, and incipiently referred to the tools and technologies including data warehouses, reporting query and analysis (Lian & Li 2012). BI helps organizations make on-time decisions to reach their goals through using an advanced tool of analysis and prediction and by covering tasks like gathering, processing and analyzing large amount of data. Ghoshal & Kim (1986) defined BI as a management philosophy in the business environment. Lönnqvist & Pirttimäki (2006) used "business intelligence" for the two following concepts:

1. Related information and knowledge of an organization, which describe the business environment, the organization itself, the conditions of the market, customers and competitors and economic issues;
2. Systemic and systematic processes, by which organizations obtain, analyze and distribute the information for making decisions about business operations.

The main purpose of BI is to help organizations to improve their performance and promote their competitive benefits in the market. Through evaluation of whether activities lead to organizations' progress toward their goals or not, BI helps in better decision-making (Mohaghar et al. 2008). By investigating the literature on BI we encounter two attitudes toward it. First, a management attitude which looks at it as a procedure in which data is gathered and organized from inside and outside of the organization to provide information related to decision-making procedures. The second attitude is technical and introduces it as a set of tools which support the aforementioned procedures. In this respect, the focus is on the algorithms and tools which provide capabilities of data storing, recovery, gathering and analyzing, instead of procedures.

2.2 PROMETHEE

PROMETHEE is a preferred structural method for evaluation and a multi criteria decision making (MCDM) method which was introduced by Brans et al. in 1986. This method is well adapted to problems where a finite number of alternative actions are to be ranked with respect to several, sometimes conflicting criteria. The first method provides a partial priority relationship for ranking the alternatives while the second method assigns a numerical privilege for each alternative which is used in ranking (Brans et al. 1986). A few years later, several versions of the PROMETHEE method have been developed. The implementation of PROMETHEE requires two additional types of information. The first one is information on the relative importance of the criteria, which is their weights, and the second one is the information on the decision maker's preference function, which the decision maker uses when comparing the contribution of the alternatives in terms of each separate criterion. In PROMETHEE, six basic types of preference functions are used: the usual function, the U-shape function, the V-shape function, the level function, the linear function and the Gaussion function. The choice of preference function depends on decision-makers and analyzers and their understanding of the relationship between the alternatives and criteria. The following parameters are used in these functions:

q: Indifference threshold.

p: Total preference threshold.

σ: It is a parameter which shows the distance between p and q.

Considering the data matrix $A = (a_1, a_2, a_3, \dots, a_n)$ with n alternatives that should be evaluated by K criteria $c = (f_1, f_2, \dots, f_k)$ with the weights of $w = (w_1, w_2, \dots, w_k)$, the steps of the PROMETHEE method are as follows:

Step 1: determination of deviations based on pair-wise comparisons of two alternatives, a and b:

$$d_j(a, b) = f_j(a) - f_j(b) \tag{1}$$

Where $d_j(a, b)$ is the difference of the value of "a" and "b" in each criterion.

Step 2: application of preference function:

$$p_j(a, b) = G_j[d_j(a, b)] \tag{2}$$

Where $p_j(a, b)$ denotes the preference of alternative "a" with regard to alternative “b” in each criterion, as a function of $d_j(a, b)$. The preference function can have a value in the range of 0 to 1 and it is interpreting the difference in terms of a specific criterion between the evaluations of a and b.

Step 3: calculation of global preference index:

$$\forall\, a, b \in A \quad \pi(a, b) = \sum_{j=1}^{k} p_j(a, b)\, w_j \tag{3}$$

Where $\pi(a, b)$ is defined as the weighted sum of $p_j(a, b)$ for each criterion.

Step 4: calculation of outranking flows for all alternatives as follow:

$$\Phi^+(a) = \frac{1}{n-1} \sum_{x \in A} \pi(a, x) \tag{4}$$

$$\Phi^-(a) = \frac{1}{n-1} \sum_{x \in A} \pi(x, a) \tag{5}$$

$$\Phi^{net}(a) = \Phi^+(a) - \Phi^-(a) \tag{6}$$

In this step $\Phi^+(a)$ is the measure of how alternative "a" dominates the other alternatives of A and $\Phi^-(a)$ gives how alternative "a" is dominated by all the other alternatives of A. $\Phi^{net}(a)$ represents a value function whereby a higher value reflects a higher attractiveness of alternative "a" and is called net flow.

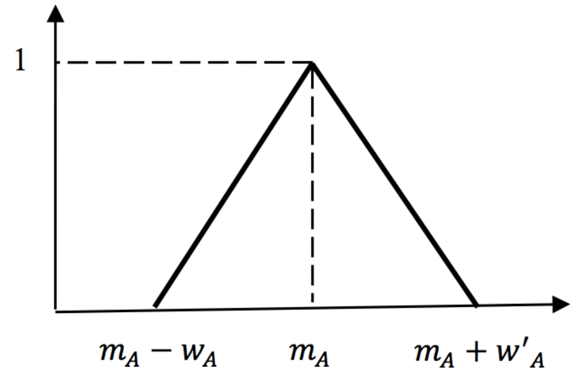

Figure 1 LR triangular fuzzy number.

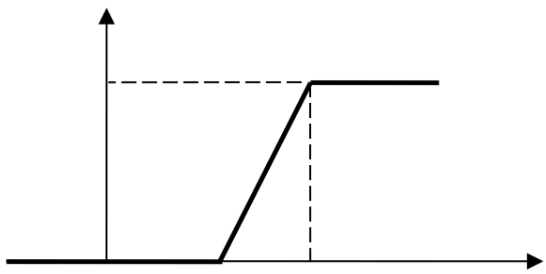

Figure 2 V-shape preference function.

PROMETHEE I is based on partial ranking, an alternative "a" is preferred to alternative "b" according to Eq. 7, alternatives "a" and "b" are indifferent according to Eq. 8 and alternatives of "a" and "b" are incomparable according to Eq. 9.

$$\begin{aligned} &\Phi^+(a) > \Phi^+(b) \ \ \& \ \ \Phi^-(a) < \Phi^-(b); or \\ &\Phi^+(a) > \Phi^+(b) \ \ \& \ \ \Phi^-(a) = \Phi^-(b); or \\ &\Phi^+(a) = \Phi^+(b) \ \ \& \ \ \Phi^-(a) < \Phi^-(b) \end{aligned} \quad (7)$$

$$\Phi^+(a) = \Phi^+(b) \ \ \& \ \ \Phi^-(a) = \Phi^-(b) \quad (8)$$

$$\begin{aligned} &\Phi^+(a) > \Phi^+(b) \ \ \& \ \ \Phi^-(a) > \Phi^-(b); or \\ &\Phi^+(a) < \Phi^+(b) \ \ \& \ \ \Phi^-(a) < \Phi^-(b); \end{aligned} \quad (9)$$

PROMETHEE II is a complete ranking whereby alternatives are ranked from the best to the worst using net flows. The alternative with the highest net flow is assumed to be superior to the others and the rest of the alternatives are ranked by their net flow values as well.

Since in some problems certain figures cannot exactly express a decision maker's opinions and conditions of the alternatives, fuzzy number and fuzzy set theory provides a thorough approach which can help remove data's ambiguity. In this paper, the Menhaj symbolizing method is used for fuzzy calculations in which the fuzzy number A is from LR type. In this way, every fuzzy number is shown by special functions, called reference functions, which determine the right and left sides of the fuzzy membership function. Figure 1 presents fuzzy number $A = (a, w_A, w'_A)$.

In this article, the fuzzy PROMETHEE method explained by Goumas and Lygerou (2000) is used. In this method, numbers used in calculations of the PROMETHEE method are fuzzy numbers. Of course, total preference and indifference thresholds (p,q) are expressed as definite numbers.

If these numbers were fuzzy, some assessments would become inexact (Goumas and Lygerou, 2000). In addition, the indices' weights can't be expressed as fuzzy numbers because in PROMETHEE the sum of indices' weights should be exactly equal to 1. The preference function applied in this paper is the V-shape function, which is shown in Figure 2.

In Figure 2, d shows the difference between two compared alternatives, q is the indifference threshold and p is the total preference threshold. If d is expressed as a fuzzy number, the V-shape preference function can be written as Eq.10.

$$P(d) = \begin{cases} 0 & (a - w_A) < q \\ \dfrac{(a, w_A w'_A) - q}{p - q} & (a - w_A) \geq q \text{ and } (a + w'_A) \leq p \\ 1 & (a + w'_A) > p \end{cases} \quad (10)$$

Fuzzy operations for calculations using fuzzy numbers to apply the above function are briefly explained in Table 1.

The overall preference of each alternative compared with other alternatives should be calculated and at the end, input and output flows and net flows should be determined for all alternatives.

By finishing the calculations, fuzzy numbers are used to make the comparisons. First, through Eq. 11, fuzzy numbers are changed to definite numbers and then comparisons are made.

$$X = a + \frac{w'_A - w_A}{4} \quad (11)$$

In Eq.11, X is a definite number equivalent to the fuzzy number (a, w_A, w'_A).

3. SUGGESTED METHOD

To evaluate BI in enterprise systems using the fuzzy PROMETHEE method, first the evaluation criteria should be identified. To do so, after studying and examining the literature on this subject, 34 factors influencing BI were identified and are mentioned in Table 2. After identifying evaluation criteria, five enterprise systems were chosen for evaluation and were named ES1, ES2, ES3, ES4, and ES5, respectively.

Table 1 Basic fuzzy operations

Type	Equation
Addition	$(a, w_A, w'_A)_{LR} + (\mathrm{b}, w_B, w'_B)_{LR} = (\mathrm{a} + \mathrm{b}, w_A + w_B, w'_A + w'_B)_{LR}$
Opposite	$-A = -(a, w_A, w'_A)_{LR} = (a, w_A, w'_A)_{RL}$
Subtraction	$(a, w_A, w'_A)_{LR} - (\mathrm{b}, w_B, w'_{\square})_{LR} = (\mathrm{a} - \mathrm{b}, w_A + w_B', w_A' + w_B)_{LR}$
Multiplication by Scalar	$c.A = c.(a, w_A, w'_A)_{LR} = (ca, cw_A, cw'_A)_{LR}$
Multiplication by fuzzy	$(a, w_A, w'_A)_{LR}.(\mathrm{b}, w_B, w'_B)_{LR} = (\mathrm{ab}, bw_{\square} + aw_B, bw'_A + aw'_B)_{LR} \quad A > 0, B > 0$ $(a, w_A, w'_A)_{LR}.(\mathrm{b}, w_B, w'_B)_{LR} \approx (\mathrm{ab}, bw_A - aw'_B, -bw'_A - aw_B)_{RL} \quad A < 0, B > 0$ $(a, w_A, w'_A)_{LR}.(\mathrm{b}, w_B, w'_B)_{LR} \approx (\mathrm{ab}, -bw'_A - aw'_B, -bw_A - aw_B)_{RL} \quad A < 0, B < 0$
Inverse	$(a, w_A, w'_A)^{-1}{}_{LR} \equiv (a^{-1}, w_A a^{-2}, w'_A a^{-2})_{RL}$
Division	$(a, w_A, w_A')_{LR} \div (\mathrm{b}, w_B, w_B')_{LR} = \left(\frac{a}{b}, \frac{bw_A + aw'_B}{b^2}, \frac{bw'_A + aw_B}{b^2}\right) \quad A > 0, B > 0$

To evaluate the above systems by a decision-making team, six linguistic values were used. These values and their equivalent fuzzy numbers are shown in Table 3. All fuzzy numbers shown in Table 3 are LR. According to linguistic values of Table 3, five alternatives were examined based on 34 criteria by the decision-making team. The fuzzy decision-making matrix for five enterprise systems of the article based on experts' judgment is shown in Table 4. In the following, the procedure of solving the problem using the fuzzy PROMETHEE method will be explained.

Table 2 Business intelligence evaluation criteria (continued on next page).

Criteria ID	**Criteria name**	**Related studies**
C1	Group wares	Shim et al. (2002), Reich & Kapeliuk (2005), Damart et al. (2007), Marinoni et al. (2009)
C2	Group decision-making	Eom (1999), Evers (2008), Yu et al. (2009)
C3	Flexibility of decision-making model	Reich & Kapeliuk (2005), Zack (2007), Lin et al. (2009)
C4	Problem clustering	Reich & Kapeliuk (2005), Loebbecke & Huyskens (2007), Lamptey et al. (2008)
C5	Optimization technique	Lee & Park (2005), Nie et al. (2008), Shang et al. (2008), Azadivar et al. (2009), Delorme et al. (2009)
C6	Learning technique	Power & Sharda (2007), Ranjan (2008), Li et al. (2009), Zhan et al. (2009)
C7	Import data from other systems	Ozbayrak & Bell (2003), Alter (2004), Shang et al. (2008), Quinn (2009)
C8	Export reports to other systems	Ozbayrak & Bell (2003), Shi et al. (2007), Shang et al. (2008)
C9	Simulation models	Power & Sharda (2007), Shang et al. (2008), Quinn (2009), Zhan et al. (2009)
C10	Risk simulation	Evers (2008), Galasso & Thierry (2008)
C11	Financial analysis tools	Santhanam & Guimaraes (1995), Raggad (1997), Gao & Xu (2009)
C12	Visual graphs	Noori & Salimi (2005), Kwon et al. (2007), Power & Sharda (2007), Li et al. (2008), Azadivar et al. (2009)
C13	Summarization	Bolloju et al. (2002), Hemsley-Brown (2005), Power & Sharda (2007), Power (2008)
C14	Evolutionary prototyping model	Fazlollahi & Vahidov (2001), Bolloju et al. (2002), Gao & Xu (2009), Zhang et al. (2009)
C15	Dynamic model prototyping	Koutsoukis et al. (2000), Bolloju et al. (2002), Goul & Corral (2007), González et al. (2008), Pitty et al. (2008)
C16	Forward and backward reasoning	Gottschalk (2006), Evers (2008), Zhang et al. (2009)

C17	Knowledge reasoning	Ozbayrak & Bell (2003), Plessis & Toit (2006), Evers (2008)
C18	Alarming and warning	Power (2008), Ross et al. (2009), Zhang et al. (2009)
C19	Recommender/ dashboard	Nemati et al. (2002), Hedgebeth (2007), Bose (2009)
C20	Combination of experiments	Courtney (2001), Nemati et al. (2002), Gottschalk (2006), Gonnet et al. (2007), Ross et al. (2009), Hewettet al. (2009)
C21	Situation awareness modeling	Raggad (1997), Plessis & Toit (2006), Feng et al. (2009)
C22	Environmental awareness	Phillips-Wren et al. (2004), Koo et al. (2008), GüngörSen et al. (2008)
C23	Fuzzy decision	Metaxiotis et al. (2003), Zack (2007), Makropoulos et al. (2008), Wadhwa et al. (2009), Yu et al. (2009)
C24	OLAP (online analysis processing tool)	Tan et al. (2003), Lau et al. (2004), Rivest et al. (2005), Shi et al. (2007), Berzal et al. (2008), Lee et al. (2009)
C25	Data mining techniques	Bolloju et al. (2002), Shi et al. (2007), Berzal et al. (2008), Cheng et al. (2009)
C26	Data warehouses	Tan et al. (2003), Tseng & Chou (2006), March & Hevner (2007), Nguyen et al. (2007)
C27	Web channel	Tan et al. (2003), Oppong et al. (2005), Anderson et al. (2007), Power (2008)
C28	Mobile channel	Power (2008), Wen et al. (2008), Cheng et al. (2009)
C29	E-mail channel	Granebring & Re'vay (2007), Baars & Kemper (2008), Wen et al. (2008)
C30	Intelligent agent	Gao & Xu (2009), Lee et al. (2009), Yu et al. (2009)
C31	Multi agent	Bui & Lee (1999), Xu & Wang (2002), Granebring & Re'vay (2007)
C32	Multi-criteria decision-making tools	Hung et al. (2007), Yang (2008), Marinoni et al. (2009), TanselIç & Yurdakul (2009)
C33	Stakeholders' satisfaction	Goodhuea et al. (2000), Lönnqvist & Pirttimäki (2006), Evers (2008), González et al. (2008)
C34	Accuracy and reliability of analysis	Gregg et al. (2002), Lönnqvist & Pirttimäki (2006), Phillips-Wren et al. (2007), Zack (2007),González et al. (2008), Power (2008)

Step 1: After determining the fuzzy decision-making matrix, the difference between each of the two alternatives is calculated as *d,* in the form of a pair. These numbers are calculated by subtraction relation, shown in Table 1.

Step 2: In this phase, the amount of P(d) is obtained through Eq. 10 with regard to the preference function used in the article.

Step 3: In this phase, the decision-making team is asked to determine the weight of each criterion by using LR fuzzy numbers. Then, by normalizing the weight of each criterion through Eq.12, which is in the form of fuzzy numbers, the definite weight of each criterion is obtained.

$$W_j = \frac{a_j}{\sum_{j=1}^{m} a_j} \tag{12}$$

Step 4: After determining the values of P_j and definite weights, the overall preference indexes should be calculated through Eq.13. In this method, $j = 1,2, \ldots, m$ indicates the criteria.

$$\pi(a,b) = \sum_{j=1}^{m} p_j(a,b).w_j \tag{13}$$

Table 3 Linguistic values and fuzzy numbers.

Linguistic value	Fuzzy number
Very low	(0 , 0, 0.2)
Low	(0, 0.2, 0.2)
Medium	(0.4, 0.2, 0.2)
High	(0.6, 0.2, 0.2)
Very high	(0.8, 0.2, 0.2)
Excellent	(1, 0.2, 0)

Step 5: In this phase, the leaving flow ($\emptyset^{+}$) and entering flow ($\emptyset^{-}$) for each alternative are calculated with regard to the amounts obtained in step 4 and by using Eq.14 and Eq.15. In these, A is a set of alternatives and n is the number of alternatives.

$$\emptyset^{+}(\mathrm{a}) = \frac{1}{\mathrm{n}-1} \times \sum_{\mathrm{x} \in \mathrm{A}} \pi(\mathrm{a},\mathrm{x}) \tag{14}$$

$$\emptyset^{-}(\mathrm{a}) = \frac{1}{\mathrm{n}-1} \times \sum_{\mathrm{x} \in \mathrm{A}} \pi(\mathrm{x},\mathrm{a}) \tag{15}$$

For example, in the problem under examination, leaving flow and entering flow values for ES1 are calculated as follows:

$$\emptyset^{+} = \frac{(\pi(\mathrm{ES1},\mathrm{ES2}) + \pi(\mathrm{ES1},\mathrm{ES3}) + \pi(\mathrm{ES1},\mathrm{ES4}) + \pi(\mathrm{ES1},\mathrm{ES5}))}{4}$$

$$\emptyset^{-} = \frac{(\pi(ES2,ES1) + \pi(ES3,ES1) + \pi(ES4,ES1) + \pi(ES5,ES1))}{4}$$

Step 6: The leaving flow and entering flow values cannot rank the alternatives completely. Therefore, another concept named the net flow value is introduced, which is an instrument for ranking all alternatives. This value is obtained through Eq.16.

$$\emptyset\,(a) = \emptyset^{+}(a) - \emptyset^{-}(a) \qquad (16)$$

Step 7: In this phase, through Eq.11, we can change net flow values that are fuzzy numbers into definite numbers and rank the enterprise systems with regard to the results.

In Table 5, the leaving and entering flow values of all five enterprise systems are shown in columns 1 and 2. The fuzzy net flow values and their definite equivalence values for different alternatives are described in columns 3 and 4. Indifference threshold is considered to be zero for all alternatives and the total preference threshold is set to 0.9.

Regarding the net flow values of five alternatives, the final ranking of the enterprise systems is: ES4, ES2, ES5, ES1 and ES3 respectively. The evaluation of the obtained results shows that the suggested method has a good performance in determining the best enterprise system.

4. CONCLUSION

A correct evaluation of enterprise systems is important for organizations' managers. BI evaluation tools and models used as a decision support system in enterprise systems can help managers to make the right choice and decisions. Therefore, in the present paper a model is presented to evaluate and rank the enterprise systems using BI and it is tested through a case study. The suggested model uses the fuzzy PROMETHEE method for evaluation and ranking, based on the PROMETHEE method as one of the best methods of multi-criteria decision-making.

Table 4 Fuzzy decision matrix.

Criteria	Alternatives				
	ES1	ES2	ES3	ES4	ES5
C1	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)
C2	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)
C3	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)
C4	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)
C5	(0.6 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)
C6	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0 ,0 ,0.2)
C7	(0.8 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0 ,0 ,0.2)
C8	(0.6 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)
C9	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.6 ,0.2 ,0.2)
C10	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)
C11	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)
C12	(1 ,0.2 ,0)	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)
C13	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(1 ,0.2 ,0)
C14	(0.8 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)
C15	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)
C16	(0.2 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)
C17	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0 ,0 ,0.2)
C18	(0.6 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)
C19	(0.8 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)
C20	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)
C21	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)
C22	(0 ,0 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0 ,0 ,0.2)
C23	(0 ,0 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)
C24	(0.6 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0.4 ,0.2 ,0.2)
C25	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)
C26	(0.8 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(1 ,0.2 ,0)	(0.6 ,0.2 ,0.2)
C27	(1 ,0.2 ,0)	(0.8 ,0.2 ,0.2)	(1 ,0.2 ,0)	(1 ,0.2 ,0)	(0.8 ,0.2 ,0.2)
C28	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(1 ,0.2 ,0)
C29	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)
C30	(0 ,0 ,0.2)	(0.6 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)
C31	(0 ,0 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0 ,0 ,0.2)	(0.4 ,0.2 ,0.2)
C32	(0.6 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.8 ,0.2 ,0.2)
C33	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)
C34	(0.6 ,0.2 ,0.2)	(0.2 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.4 ,0.2 ,0.2)	(0.6 ,0.2 ,0.2)

Table 5 Ranking with PROMETHEE. Alt. = alternative, D∅ = defuzzied ∅, R = rank

Alt.	$\emptyset^{+}$			$\emptyset^{-}$			$\emptyset^{net}$			D ∅	R
ES1	(0.596	,0.057	,0.046)	(0.085	,0.075	,0.043)	(-0.026	,0.100	,0.121)	-0.0209	**4**
ES2	(0.074	,0.097	,0.075)	(0.054	,0.050	,0.035)	(0.019	,0.132	,0.125)	0.0174	**2**
ES3	(0.046	,0.044	,0.022)	(0.080	,0.100	,0.081)	(-0.033	,0.125	,0.122)	-0.0367	**5**
ES4	(0.112	,0.100	,0.069)	(0.050	,0.046	,0.029)	(0.062	,0.130	,0.115)	0.0586	**1**
ES5	(0.076	,0.064	,0.041)	(0.097	,0.092	,0.065)	(-0.021	,0.129	,0.133)	-0.0204	**3**

In order to remove the problems and ambiguities that result from changing the observations to definite variables; fuzzy numbers are used in the calculations of the PROMETHEE method. Here, 34 criteria were examined to evaluate the enterprise systems identified by reviewing the literature.

To improve and develop the present study, the following ideas are suggested for further research;

1. Using other multi-criteria decision-making models to rank enterprise systems;
2. Investigating other multi-criteria decision-making models in fuzzy and definite moods and comparing the results with each other;
3. Finding the most influential and the most influenced factors among the 34 factors.

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