vol.2, No. 3(s), pp. 1374-1386 ISSN 1805-3602

Using combinational method DEMATEL and ANP with fuzzy approach to evaluate business intelligence performance

Fakhrieh Sadehnezhad[1], Mansur Zaranejad[2], Albroz Gheitani[3]

[1]Shushtar Branch, Islamic Azad University, Shushtar, Iran; [2]Financial Management. Chamran University and Shushtar Branch, Islamic Azad University, Shushtar, Iran; [3]Management Department. Shushtar Branch, Islamic Azad University, Shushtar, Iran

Abstract

As the effective evaluation of productivity of information systems is the important element in the success of each system, the present study evaluated business intelligence performance as the most complete information system. To do this, after the review of literature, the initial model of the study was designed by considering five main criteria including adjustment with the business needs and users, system function, providing the organization requirements and integration ability, system flexibility and integration of experiences and needs with 14 sub-criteria in accordance with Lin studies (2009), Haqiqat Monfared (2010). To evaluate the system, based on the effect and dependency of the various factors on BI performance, DEMATEL and network analysis process combination with fuzzy approach with super decision software and Excel was used. Thus, decision-making problem was considered in three levels as data structure network and by achieving the knowledge of the decision makers in the form of linguistic terms via pair-wise comparison questionnaire, the linguistic terms with their meaning were replaced in triangular fuzzy number. The results of the study can be the guidance of implementation of business intelligence that the organization based on system performance evaluation priorities allocates its resources as financial and time resources to improve the organizational goals.

Keywords: Business intelligence systems, Network analysis method, DEMATEL technique, Fuzzy logic, Fuzzy network analysis

Introduction

The social-economical reality of the contemporary organizations obliged them to search some tools to facilitate the process of data effective achievement, their extensive processing by which a basis to discover new knowledge is considered. TO search these tools, the existing management information systems as MIS,DSS, ESS,EIS were used for a long time. But these systems couldn't integrate the dispersed, heterogeneous data and good identification of the existing dependencies among the new data and in order that the organizations can react rapidly to the market changes, the management information system is required to do causal analyses of the organization and its environment (Olszak & Ziemba). Business intelligence is not only considered as a product or tool or even a system but also as a new approach in organizational architecture based on the speed in data analysis to take exact and intelligence business decisions at the minimum time as a solution for the current organizations. By business intelligence process, it can be said "What happened in the system"? by existing data processing, the question is answered:" Why this event is occurred?" finally by the decision taken by the managers, it can be predicted that "what will happen?"

There are various problems in implementation of such new approaches. The business intelligence in the organization considers all the users and the relations of them to cover enterprise value chain perfectly. Based on this logic that if incomplete or wrong information are entered into the system or organization, its output is not evaluated well and if the best mechanisms are given to unsuitable people, by reducing their useful life, its efficiency is not considerable. Thus, the orga-

Corresponding author: Fakhrieh Sadehnezhad, Shushtar Branch, Islamic Azad University, Shushtar, Iran. E-mail: fsadehneghad@yahoo.com

nization should evaluate business intelligence performance based on criteria and by taking considerable costs and time for general changes, don't have considerable damages in the output. In case of failure, referring to the first point and modification of the mistakes or new changes are not possible. Thus, the top managers as using business intelligence is a new approach by evaluating this system find about the logicality and correctness of their selection.

Limited attempts are done to evaluate business intelligence and business intelligence is considered as a single system not in the organizational system. Lonnqvist and Pirttimki (2006) in a study designed the set of criteria of business intelligence perforamnce and before them the researchers conducted some studies with the aim of proving the need to the investment nad vlaue and busienss intelligence . Elbashir *et al.*, 2008 (2008) in a study focused on the effect of business intelligence systems in busines sprocess and presented an effect measurment method.

Lin *et al.* (2009) developed performance evaluation model of a single business intelligence system by network analysis process method. But they evaluated business intelligence separated form organizational system. In this study, to determine the sub-criteria, 12 experts were consulted. The results of the study showed that the most important effective factors on efficiency of BI system are output accuracy and validity of information, adjusting with the requirements and supporting the organizational productivity. The application of business intelligence evaluation followed two general aims. The first and the most common aim of business intelligence measurement are proving its value for investment (Sawka, 2000). Helping the development process of business intelligence and being sure of the business intelligence products of the real requriements of the organization and users are met. The second aim and the reason is the measruemnt and evalaution of organizatioanl intelligence. The improtance of application of evaluation of the system is increased in educational centers as the most important concern of educational system of a country, suitable ground to promot intellectual capital in information-based community . Based on the signifiance of the study, based on the previous studies and delphi method (in intelligence excutional companies of educational centers of Khuzestan province), 5 criteria were considered including the adjustment with the business and users needs, business intelligence function, system flexibility, meeting the requirments of the organization and integration of the experiences and needs, evaluation of the performance of business intelligence systems. The evaluation of BI system perforamnce is a complex process due to being influenced by various quantitative and qualitative faactors. In addition, the existing uncertainity in quantitative and qualitative criteria increased this complexity. To interact with the complexities, nework analysis tecnique based on fuzzy theory was formed and by considering this important aim, the evaluation of business intelligence systems perormance by fuzzy network analyssi was presented and it is expected that this study theoretically :

- It increases the knowledge and literature of business intelligence systems namely the performance evaluation method.
- Identify the factors as effective in the success of business intelligence systems of the organizations producing the software based on the past studies.
- A ground for more researches to develop the knowledge of BI contemporary systems and provided the motivation for the organizations to use the system. If business intelligence system is used in the organizations and companies, all the daily works of the employees are done in the portal and there is no need to investigate the entrance fund separately, various software, working with separate files, etc.

In methodology of the study:

- The applied model based on fuzzy net work analysis for evaluation of the performance of business intelligence systems was presented. The results showed that based on fuzzy calculations, the business needs criterion was more preferred. Business intelligence system function is on the second preference and system flexibility criterion, meeting the organization requirements and integration were in the new ranks.

The present study introduced business intelligence system and finally the evaluation of business intelligence was modeled. A brief explanation of the paper is investigated based on theoretical basics of business intelligence; network analysis and fuzzy logic were considered. BI was introduced for the first time in 1989 by Howard Dresner from the Gartner group to describe a series of designed concepts with the aim of improving decisions in business by reality-based systems. BI presented the business information on time and provided the ability of hidden meaning concepts in business information (Azoff & Charlesworth, 2004). Indee, business intelligence refers to management philosophy help ing the organizations to mange the business information to take effective decsions (Ghoshal & Kim, 1986).

The need to business intelligence starts from the highest organizational ranks and in the highest management pyramid level, the business intelligence feelings is aroused and are transferred to the lower level from the layers. While for launching business intelligence, we should start from the lowest organization layers. As the required data and business intelligence tool started from the lower layers of production. In the first layer of this architecture, service provider of analytic warehouse that is the relational data base system. This layer extracts the required data from the operational data and external resources and flat files, etc to create data warehouse. In the middle layer, a service provider is an *Online Analytical* Process by which multi-dimensional cubic is built. *Online Analytical* Process is strong, rapid and suitable tool for reporting. In the last layer, reporting and data analysis tools are required. To implement a data warehouse, each of the layers are implemented accurately. Jalonen & Lonnqvist (2009) stated that business intelligence produced analysis of business environment process and internal issues of the organization and the analyses can be provided as automaticlaly and systematic or based on the special conditions and they are related to the content of a specific decsion and the obtained knowledge is used by decsion maker in various levels of organization . Due to the influence of business intelligence performance of various factors, multi-criteira decsion making tecniques were used to evaluate the business intelligence system. ANP is acronym of Analytical Network Process. ANP is the evolved form of Analytic Hierarchy Process (AHP). In AHP, the dependencies should be linear and top to bottom or vice versa. But if the dependencies are two directional, the weight of criteria is related to the weight of choices and weight of the choices to the weight of criteria. Then, this is not hierarchy and we cannot use hierarchy analytic formula. Saaty (1996) presented the developed method of Analytic Network Process (ANP).

For modeling the problem, a network is plotted in which the existing nodes in this network are equal to the goal, criteria and choices. The directional vectors linking these nodes show the direction of the effect of nodes on each other. Goal is in the first level of the network and the main factors are in the second level and the main factors have internal dependency and sub-factors are in the third level. To form super matrix, at first

The main criteria based on goal are compared as pair-wise: W21

The main criteria are compared based on each criterion as pair-wise: W22

The sub-criteria of each criterion are compared based on the criterion as pair-wise: W32

The set of existing sub-criteria is compared as pair-wise: W33

The set of calculations form the structure of asymmetrical super matrix as plotted in the following figure. By normality concept, the unweighted supermatrix is converted to weighted supermatrix (normal). In weighted supermatrix, the sum of the elements of all the columns is equal to one. The weighted supermatrix is extracted of super decision software. Finally, limit supermatrix is computed. Limit supermatrix is obtained by raising all the elements of weighted supermatrix to power. This is repeated until all the elements of super matrix are similar. In this case, all the elements of supermatrix are equal to zero and the only elements of sub-criteria are the number being iterated in all rows of the element. The supermatrix of the computed limit with super decision software can obtain the final priority of the indices. Most of the researchers believed that due to the uncertainty in the response of the experts, during the pair-wise comparison and allocation, this type of decision making is uncertain (Leong, Cao, 2002). In collection of the comments of the experts, linguistic fuzzy items were applied in pairwise comparison questionnaire. Yurdakul and Iç studied the benefits of fuzzy number in multi-criteria decision making. They recommended fuzzy number when there were many ambiguities in the data (Yurdakul, M., and Iç, 2009). Fuzzy logic is a kind of logic replacing the conclusion methods in the mind of human beings and introduces a function for membership in a set to express the ambiguity in the form of a number and a real number ranging 0,1 is dedicated to each element. This number shows the membership degree of the element to the required set. Zero element membership shows that the required element is out of the set while 1 indicates that the required element is completely in the set (Renu, 2010). The simplest membership function is consisting of direct lines. This function is triangular membership function called trimf. This function is consisting of three points forming a triangular. Indeed, the most applied fuzzy number is triangular fuzzy number as shown in Chart (2-7) as m is exponent, α the distance of exponent to the lower limit and β is the distance of exponent to the upper limit. For triangular fuzzy number, all mathematical operation is defined. The triangular number membership function is as:

$$\mu_M(x) = \left\{ \begin{array}{ll} 1-\dfrac{m-x}{\alpha}, & (m-\alpha) \le x \le m \\ 1-\dfrac{x-m}{\beta}, & m \le x \le (m+\beta) \\ 0, & \text{others} \end{array} \right\}$$

Materials and Methods

The present study was applied in terms of aim and descriptive-explorative in terms of data collection. It is descriptive as the descriptive study is the set of methods and the aim is describing the studied phenomena. The present study describe the business intelligence performance via considering the features, dimensions and the limits and as it attempted to present a model by DEMATEL, ANP combinational method with fuzzy approach, it is also considered modeling. The study population was all the companies manufacturing intelligence plan software of the educational centers in Khuzestan province. The present study considered the basis of data collection as the specialization and skill of the people in business intelligence. Organized sampling was applied. This sampling is the best method to apply the comments of people being skillful in a specific subject. 11 experts on implementation of business intelligence were identified. For data collection, library and field study was used. For review of literature (theoretical basics and review of literature) and the selection of the criteria and study indices, library method, journals, conferences and valid scientific sites were applied. The main study data to study the study questions were obtained via field method via distributing the questionnaire among the experts based on Delphi method. The questionnaire of the study was consisting of three parts:

First section- Pair-wise comparisons of the main criteria to the goal

Second section- Pair-wise comparisons of the main criteria with each other (interactions of the main criteria with each other)

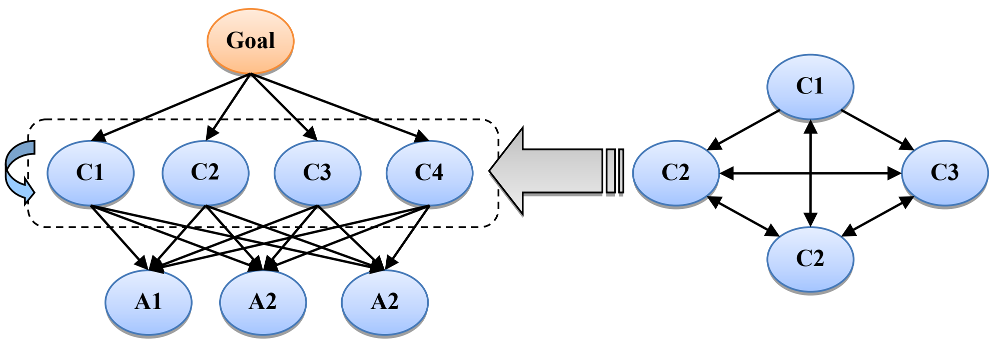
Third section- Pair-wise comparisons of the selected indices with the main criteria

The design of the questions was as the respondents should select response ranging 1 to 9 for each choice. Indeed, the experts responses were converted to triangular fuzzy number (m, α, β) by the matrix extracted by study population and the table of converting the linguistic items to fuzzy number. To evaluate the content validity of the questionnaire, Delphi and expert techniques were applied. Then, the content validity of the questionnaire was verified by the experts. Content validity measured the questions of the variable being provided. Its evaluation method is mostly based on specialized judgment and experiences of professional people. According to construct validity, as the study process was based on theoretical framework, the construct validity is defined and as the extraction of the factors is relied upon many papers and articles, it seems that prediction validity is fulfilled. To measure the reliability of this study, besides using the calculations of incompatibility rate of the responses of each expert, the incompatibility rate of collecting the experts' comments was calculated and the reliability of the study was supported. After the collection of the questionnaires, the information was classified and FANP technique was used to weight each of the indices. Then, the data entered excel and by Super decision software, the study models were designed.

Combinational FANP-DEMATEL approach

The network analytic method let the decision maker built a network instead of hierarchy. This made the investigation of internal relation between the elements as possible. The relative importance of the elements of each cluster was similar to the hierarchy analysis method based on pair-wise comparison. But, determining the relation in network structure or determining the mutual dependence degree between the criteria is the most important issue in network analysis method.

The internal relations are evaluated by DEMATEL technique. The benefit of this method to network analytic technique is its transparency in reflecting the mutual relations between a wide set of elements as the experts can give their comments in relation to the effects (direction and severity of the effects) between the factors. It can be said that final matrix of DEMATEL technique (internal relations matrix) formed a part of supermatrix. DEMATEL technique doesn't act separately and it acts as a sub-system of a great system as ANP.



b. Prioritization with ANP

a. Identification of the relations with DEMATEL

Figure 1. Combinational approach ANP-DEMATEL

Achieving the final priorities of each of the indices with combinational approach ANP-DEMATEL requires four main steps:

- First step: Pair-wise comparison of the main criteria based on aim (W21) by pair-wise comparison
- Second step: The identification of the relations between the main criteria (W22) by DEMATEL technique
- Third step: Pair-wise comparison of the elements of each of main criteria (W32) by pair-wise comparison
- Fourth step: The identification of the relations between the final indices (W33) by DEMATEL technique

The output of each of the above steps is in a wide matrix as unweighted supermatrix. The structure of this supermatrix is presented. In this exponent, zero elements showed the ineffectiveness of the factors in intersection of the row and column on each other.

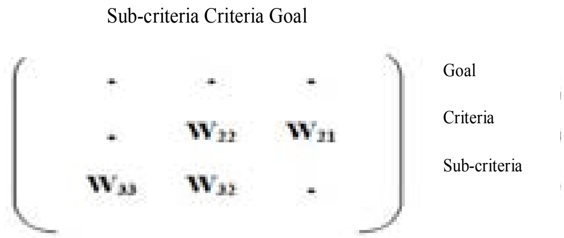


Figure 2. The structure of initial or unweighted supermatrix

The design of Analytic Network Process (ANP)

Based on the aim of the study, at first based on the identified criteria and sub-criteria, the network analysis model was designed in super decision software. Based on this model, ANP chart is as shown in Figure 3.

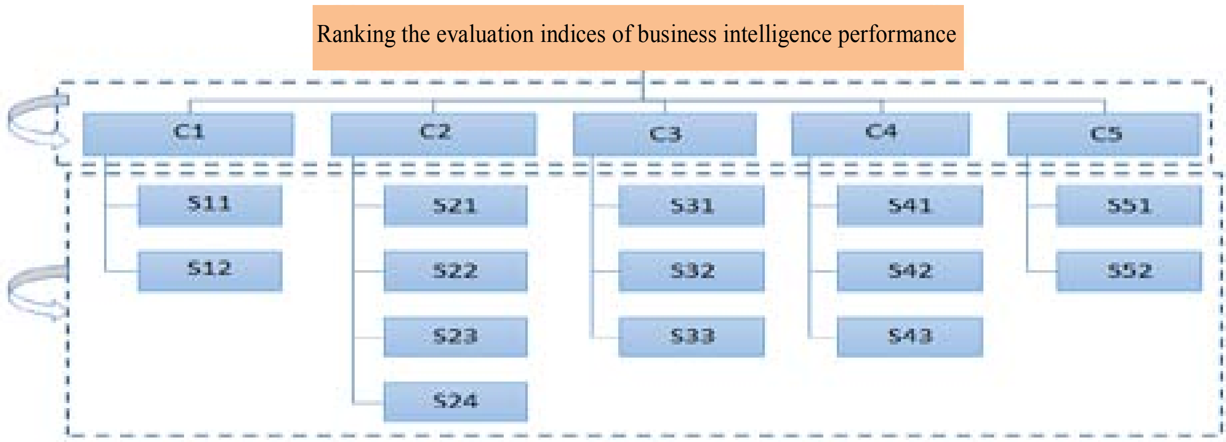


Figure 3. ANP chart of the priority of the criteria and evaluation indices of business intelligence performancee

For pair-wise comparison of the elements Saaty 9-degree elements was applied. Saaty 9-degree scale was proposed by hierarchy analysis theory. In this study, for quantification of the values, fuzzy approach was used. Fuzzy scale corresponding with Saaty 9-degree in fuzzy network analytic process are shown in Table 2.

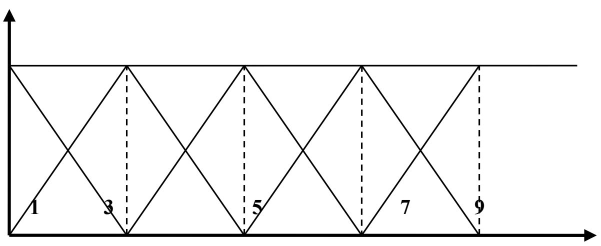


Figure 4. The linguistic variables with triangular fuzzy number

The calculations of Fuzzy Analytic Network Process (FANP)

In this stage, the fuzzy calculations of the comparison of the criteria and sub-criteria of the model based on the study purpose. The computations were done with fuzzy coding in Excel.

First, the main criteria based on goal are prioritized (W21) with fuzzy calculations. Then, fuzzy average of the views of people was calculated. To calculate the average of the comments of n respondents, the mean of fuzzy is calculated as:

$$\text{fuzzyaverage} = \left[\frac{l_1 + l_2 + \ldots + l_n}{n}, \frac{m_1 + m_2 + \ldots m_n}{n}, \frac{u_1 + u_2 + \ldots + u_n}{n} \right]$$

The results of pair-wise comparisons are shown in Table 3.

Table 1. The criteria and sub-criteria of the model and the applied indices

Main criteria		Sub-criteria	Index
Adjusting with the user's needs	C1	Meeting the users demands	S11
		Consistency of the system with strategic goals	S12
The business intelligence system function	C2	Application simplicity factors and data visualization ability	S21
		The accuracy of output data	S22
		System security	S23
		System response time	S24
System flexibility	C3	Comfort factors of applying changes in the system	S31
		Flexibility and parametric nature of the output reports	S32
		Future development of the system	S33
Meeting the demands of organizations	C4	Users participation factor	S41
		Supporting the organization efficiency	S42
		Supporting decision making	S43
The ability of integration of the experiences and needs	C5	The factors of using the application of the experiences	S51
		Integration of the information needs of the business performers	S52

Table 2. The linguistic variables scale with triangular fuzzy number Li et al., (2008)

Value	Comparing i to j	Fuzzy number			Inverse fuzzy number		
		l	m	u	l	m	u
1	Equally Preferred	1	1	1	1	1	1
2	Intermediate	1	2	3	0.333	0.5	1
3	Moderately Preferred	2	3	4	0.25	0.333	0.5
4	Intermediate	3	4	5	0.2	0.25	0.333
5	Strongly Preferred	4	5	6	0.166	0.2	0.25
6	Intermediate	5	6	7	0.142	0.16	0.2
7	very strongly Preferred	6	7	8	0.125	0.142	0.166
8	Intermediate	7	8	9	0.111	0.125	0.142
9	Extremely Preferred	9	9	9	0.111	0.111	0.111

Table 3. The fuzzificated matrix of pair-wise comparison of the main criteria

C5	C4	C3	C2	C1	
(4.93, 5.43, 5.93)	(3.56, 3.87, 4.19)	(5.04, 5.25, 5.46)	(2.96, 3.17, 3.38)	(1, 1, 1)	C1
(4.64, 5.14, 5.65)	(5.53, 6.04, 6.55)	(3.26, 3.67, 4.08)	(1, 1, 1)	(0.3, 0.32, 0.34)	C2
(4.72, 5.43, 6.13)	(3.54, 4.15, 4.75)	(1, 1, 1)	(0.25, 0.27, 0.31)	(0.18, 0.19, 0.2)	C3
(6.11, 6.61, 7.11)	(1, 1, 1)	(0.21, 0.24, 0.28)	(0.15, 0.17, 0.18)	(0.24, 0.26, 0.28)	C4
(1, 1, 1)	(0.16, 0.15, 0.16)	(0.16, 0.18, 0.21)	(0.18, 0.19, 0.22)	(0.17, 0.18, 0.2)	C5

The extension of fuzzy compound for each of the criteria

The fuzzy sum of the elements of each row is calculated as:

$$\sum_{j=1}^{5} M_{g_1}^{j} = (1.00, 1.00, 1.00) \oplus (2.96, 3.17, 3.38) \oplus (5.04, 5.25, 5.46) \oplus (3.56, 3.87, 4.19) \oplus (4.93, 5.43, 5.93)$$

$$\sum_{j=1}^{5} M_{g_2}^{j} = (0.30,0.32,0.34) \oplus (1.00,1.00,1.00) \oplus (3.26,3.64,4.08) \oplus (5.53,6.04,6.55) \oplus (4.64,5.14,5.65)$$

$$\sum_{j=1}^{5} M_{g_3}^{j} = (0.18,0.19,0.20) \oplus (0.25,0.27,0.31) \oplus (1.00,1.00,1.00) \oplus (3.54,4.15,4.75) \oplus (4.72,5.43,6.13)$$

$$\sum_{j=1}^{5} M_{g_4}^{j} = (0.24,0.26,0.28) \oplus (0.15,0.17,0.18) \oplus (0.21,0.24,0.28) \oplus (1.00,1.00,1.00) \oplus (6.11,6.61,7.11)$$

$$\sum_{j=1}^{5} M_{g_5}^{j} = (0.17,0.18,0.20) \oplus (0.18,0.19,0.22) \oplus (0.16,0.18,0.21) \oplus (0.16,0.15,0.16) \oplus (1.00,1.00,1.00)$$

Thus,
$\sum mg_1$ = (17.491,18.718,19.957)
$\sum mg_2$ = (14.728,16.165,17.614)
$\sum mg_3$ = (9.690,11.034,12.389)
$\sum mg_4$ = (7.713,8.276,8.855)
$\sum mg_5$ = (1.672,1.714,1.793)

The fuzzy sum of the elements of sum column is calculated:

$$\sum_{j=1}^{5} \sum_{j=1}^{5} M_{g_6}^{j} = (17.491,18.7181,19.9576) \oplus (14.72892803,16.16518646,17.61443784) \oplus (9.690815401,11.03478826,12.38904893)$$
$$\oplus (7.713063087,8.276157109,8.85507689) \oplus (1.672247323,1.714186417,1.793925753)$$

The sum of the elements of inverse average column is as:

$\sum\sum m_{g1}$ = (51.296, 55.908, 60.610)

$$\left(\sum_{j=1}^{6} \sum_{j=1}^{6} M_{g}^{j}\right)^{-1} = (0.016, 0.018, 0.019)$$

To normalize the average of the preferences of each criterion, the average of the criterion is divided by the sum of averages. As the values are fuzzy, the fuzzy average of each row is multiplied by the inverse sum of fuzzy average. The inverse sum of fuzzy average in the third step is calculated. Thus,

S1=(17.491,18.718,19.957)⊗(0.016,0.0183,0.019)=(0.289, 0.335, 0.389)
S2=(14.728,16.165,17.614)⊗(0.016,0.0183,0.019)=(0.243, 0.289, 0.343)
S3=(9.690,11.034,12.389)⊗(0.016,0.0183,0.019)=(0.160, 0.197, 0.242)
S4=(7.713,8.276,8.855)⊗(0.016,0.0183,0.019)=(0.127, 0.148, 0.173)
S5=(1.672,1.714,1.793)⊗(0.016,0.0183,0.019)=(0.028, 0.031, 0.035)

The calculation of preference degree (possibility degree) of a convex fuzzy number S greater than K convex fuzzy number S_i;i=1,2,...,k.

V(S1≥S2,S3,S4,S5)=min(V(S1≥S2), V(S1≥S3), V(S1≥S4), V(S1≥S5))=1.000
V(S2≥S1,S3,S4,S5)=min(V(S2≥S1), V(S2≥S3), V(S2≥S4), V(S2≥S5))=0.546
V(S3≥S1,S2,S4,S5)=min(V(S3≥S1), V(S3≥S2), V(S3≥S4), V(S3≥S5))=0.521
V(S4≥S1,S2,S3,S5)=min(V(S4≥S1), V(S4≥S2), V(S4≥S3), V(S4≥S5))=0.237
V(S5≥S1,S2,S3,S4)=min(V(S5≥S1), V(S5≥S2), V(S5≥S3), V(S5≥S4))=0.119

Fourth stage: Normalization of W' vector and obtaining normalized vector W.

W'=(1.000,0.546,0.521,0.237,0.119)

W_N=(0.413,0.225,0.215,0.098,0.049)

Thus, Eigen vector W_{21} is as following:
Vector W21

$$\mathbf{W_{21}} = \begin{pmatrix} 0.413 \\ 0.225 \\ 0.215 \\ 0.098 \\ 0.049 \end{pmatrix}$$

The result of fuzzy calcualtions for prioritization of the main criteria based on the goal is shown in Figure 4.

Table 4. The calculation of preference degree (possibility degree) S_i on S_k

	L	M	U	final
V(S1>S2)	0.289	0.335	0.389	1
V(S1>S3)	0.289	0.335	0.389	1
V(S1>S4)	0.289	0.335	0.389	1
V(S1>S5)	0.289	0.335	0.389	1
V(S2>S1)	0.243	0.289	0.343	0.5455
V(S2>S3)	0.243	0.289	0.343	1
V(S2>S4)	0.243	0.289	0.343	1
V(S2>S5)	0.243	0.289	0.343	1
V(S3>S1)	0.160	0.197	0.242	0.5208
V(S3>S2)	0.160	0.197	0.242	0.0165
V(S3>S4)	0.160	0.197	0.242	1
V(S3>S5)	0.160	0.197	0.242	1
V(S4>S1)	0.127	0.148	0.173	1.6375
V(S4>S2)	0.127	0.148	0.173	0.9952
V(S4>S3)	0.127	0.148	0.173	0.2372
V(S4>S5)	0.127	0.148	0.173	1
V(S5>S1)	0.028	0.031	0.035	0.1192
V(S5>S2)	0.028	0.031	0.035	4.125
V(S5>S3)	0.028	0.031	0.035	2.989
V(S5>S4)	0.028	0.031	0.035	3.679

As it can be said, based on fuzzy calculations, business needs criterion is highly preferred and business intelligence system function is in the second rank of preference. The preference of other criteria is not changed compared to the past.

The calculations of internal relations with FDEMATEL technique

Based on the study model, the second step is calculation of the internal relations of the main criteria. Thus, the matrix of main criteria relations W22 is obtained. To reflect the internal relations of the main criteria, fuzzy DEMATEL technique is used and the experts can express their views about the effects (direction and severity of the effects) between the factors. It can be said that the matrix of DEMATEL technique (internal relations matrix) showed the causal relation between the factors and showed also the effect of the variables. The applied fuzzy spectrum is shown in Table 5.

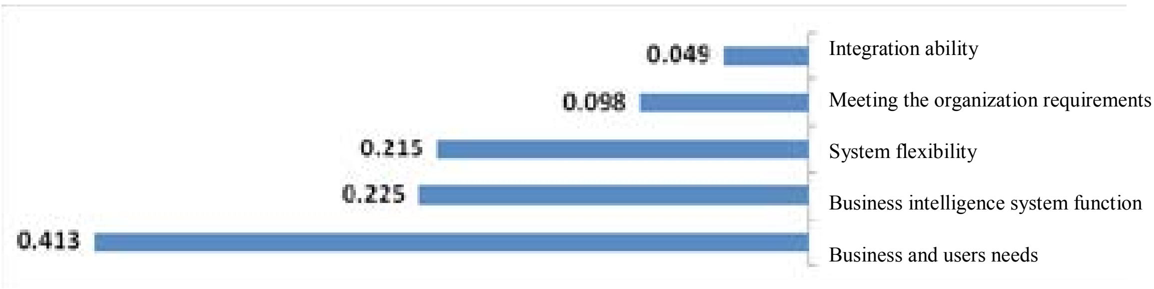


Figure 4. The prioritization of the main criteria based on the study aim

Table 5. Fuzzy spectrum and DEMATEL technique (source: Wang, 2011; Wang and Chang, 1995)

Linguistic variable	Quantity equivalent	Fuzzy quantity equivalent		
		l	m	u
No effect	0	0.0	0.1	0.3
Low effect	1	0.1	0.3	0.5
Effective	2	0.3	0.5	0.7
Much effect	3	0.5	0.7	0.9
Very much effect	4	0.7	0.9	1

The calculation of direct relation matrix (M)

In DEMATEL technique, when the views of some experts are used, the simple calculation average of the comments is used and direct relation matrix or M is formed. In this study, first the views of the experts one by one is fuzzificated and by the calculation of fuzzy average of the experts view, the direct relation matrix or M is calculated.

Table 6. The matrix of fuzzificated direct relation (M)

C5	C4	C3	C2	C1	
(0.38, 0.58, 0.78)	(0.42, 0.62, 0.8)	(0.28, 0.48, 0.68)	(0.56, 0.76, 0.92)	(0, 0.1, 0.3)	C1
(0.22, 0.42, 0.62)	(0.26, 0.46, 0.66)	(0.26, 0.46, 0.66)	(0, 0.1, 0.3)	(0.24, 0.44, 0.64)	C2
(0.44, 0.64, 0.83)	(0.46, 0.66, 0.84)	(0, 0.1, 0.3)	(0.52, 0.72, 0.88)	(0.52, 0.72, 0.88)	C3
(0.24, 0.44, 0.64)	(0, 0.1, 0.3)	(0.2, 0.4, 0.6)	(0.34, 0.54, 0.74)	(0.28, 0.48, 0.68)	C4
(0, 0.1, 0.3)	(0.34, 0.54, 0.74)	(0.18, 0.38, 0.58)	(0.3, 0.5, 0.7)	(0.36, 0.56, 0.76)	C5

Making direct relation matrix crisped

For defuzzification of direct relation matrix, CFCS technique was used. Defuzzification method of CFCS[1] is applied for fuzzy accumulating process and the defuzzificated values are presented better (Opricovic, 2003[2]; Wu, 2007; Chang *et al*[3]., 2011). CFCS method is calculated based on Max and Min values of fuzzy number in each range. CFCS method is a 5-stage algorithm:

- Values normalization

$$l_{ij}^{n}=\left(l_{ij}^{d}-minl_{ij}^{d}\right)/\Delta_{min}^{max}$$

$$m_{ij}^{n}=\left(m_{ij}^{d}-minl_{ij}^{d}\right)/\Delta_{min}^{max}$$

$$u_{ij}^{n}=\left(u_{ij}^{d}\text{-}minl_{ij}^{d}\right)/\Delta_{min}^{max}$$

$$where\Delta_{min}^{max}=maxu_{ij}^{d}-min_{ij}^{d}$$

- The calculation of upper and lower limit of normal values

$$ls_{ij}^{n}=m_{ij}^{n}/\left(1+m_{ij}^{n}-l_{ij}^{n}\right)$$

$$us_{ij}^{n}=u_{ij}^{n}/\left(1+u_{ij}^{n}-m_{ij}^{n}\right)$$

- The calculation of total crisp normalized values

$$x_{ij}^{n}=\left[xls_{ij}^{n}\left(1-xls_{ij}^{n}\right)+xrs_{ij}^{n}\times xrs_{ij}^{n}\right]/\left[1-xls_{ij}^{n}+xrs_{ij}^{n}\right]$$

- The calculation of crisp values

$$Z_{ij}^{n}=minl_{ij}^{n}+\left(X_{ij}^{n}\times\Delta_{min}^{max}\right)$$

Based on CFCS algorithm, the crisp values of direct relations matrix are as following:

Table 7. The matrix of direct relation (M) of the crisp main criteria

M	C1	C2	C3	C4	C5
C1	0.126	0.740	0.468	0.605	0.570
C2	0.440	0.126	0.450	0.458	0.420
C3	0.700	0.701	0.128	0.643	0.625
C4	0.478	0.536	0.395	0.127	0.438
C5	0.553	0.498	0.377	0.533	0.127

- The calculation of normal direct relation matrix : N = K*M

At first, the sum of all the rows and columns is calculated. The inverse of the greatest number of k row and column is formed. According to Table 7, the greatest number is 2.796 and all the values of this table are multiplied by the inverse of this number to normalize the matrix.

$$k=\frac{1}{\max\sum_{j=1}^{n}a_{ij}}=\frac{1}{2.796}=0.357$$

$$\Rightarrow N=0.357{*}M$$

Table 8. Normalized matrix (N) of the main criteria

N	C1	C2	C3	C4	C5
C1	0.0452	0.2646	0.1674	0.2163	0.2036
C2	0.1573	0.0450	0.1609	0.1636	0.1501
C3	0.2503	0.2508	0.0457	0.2299	0.2233
C4	0.1708	0.1915	0.1412	0.0453	0.1568
C5	0.1977	0.1780	0.1347	0.1904	0.0453

The calculation of total relation matrix

To calculate the total relation matrix, at first identity matrix (I) is formed. Then, the identity matrix is minus the normal matrix and the result matrix is inversed and finally normal matrix is multiplied by inverse matrix:

$$T=N\times\left(I-N\right)^{-1}$$

[1]Converting Fuzzy data into Crisp Scores, CFCS

[2]Opricovic, S., Tzeng, G.H. (2003).Defuzzification within a multi-criteria decision model. International Journal of Uncertainty, Fuzzine C and Knowledge-based Systems, 11, 635–652

[3]Chang, Betty, Chih-Wei Chang, Chih-Hung Wu., (2011). Fuzzy DEMATEL method for developing supplier selection criteria, Expert Systems with Applications 38, pp. 1850–1858

Table 9. Total relation matrix (T) of main criteria

T	C1	C2	C3	C4	C5
C1	0.7516	1.0236	0.7372	0.9210	0.8582
C2	0.7060	0.6749	0.6094	0.7285	0.6760
C3	1.0043	1.1038	0.6944	1.0143	0.9507
C4	0.7319	0.8209	0.6076	0.6392	0.6964
C5	0.7821	0.8437	0.6265	0.7966	0.6243

Showing the network relations map

To determine the Network Relations Map (NRM), the threshold value is calculated. By this method, partial relations are ignored and reliable relation network is drawn. The only relations their values are bigger than threshold value in matrix T is shown in NRM. To calculate the threshold value of the relations, it is required to calculate the average values of matrix T. After the determination of threshold value, all the values of matrix T less than threshold is zero, the causal relation is not considered. In this study, threshold value is 0.785. Thus, the model of significant relations is as:

Table 10. The model of significant relations of the main criteria of the model

	C1	C2	C3	C4	C5
C1	×	1.0236	×	0.9210	0.8582
C2	×	×	×	×	×
C3	1.0043	1.1038	×	1.0143	0.9507
C4	×	0.8209	×	×	×
C5	×	0.8437	×	0.7966	×

Based on relations model, the casual chart is drawn as:

Table 11. The model of causal relations of business intelligence indices

	D	R	D+R	D-R
The needs of business and users	4.292	3.976	8.268	0.316
Business intelligence system function	3.395	4.467	7.862	-1.072
System flexibility	4.767	3.275	8.042	1.492
Meeting the organization requirements	3.496	4.100	7.596	-0.604
Integration ability	3.673	3.806	7.479	-0.133

In the sum of the elements of each row (D) showed its effect on other system factors. Thus, system flexibility criterion had the major influence. The business and users needs criteria were in the second rank. The integration ability and organization requirement with similar effect was in the next position. The business intelligence system criterion had the lowest effect.

- The sum of column elements for each factor indicates its effect from other system factors. Thus, business intelligence system function has considerable effect. The system flexibility had the lowest effect from other criteria.

Horizontal vector (D+R) is the effect of the required model in the system. In other words, the more the value of D+R, the more the interaction of the factor with other factors of the system. Thus, business and users needs criterion had the major interaction with other study criteria. The integration ability criterion had the lowest interaction with other variables.

- Vertical vector (D-R) showed the power of effect of each factor. Generally, if D-R is positive, the variable is causal and if it is negative, it is effect. In this model, business and users needs and flexibility of the system were casual and other variables were effect.

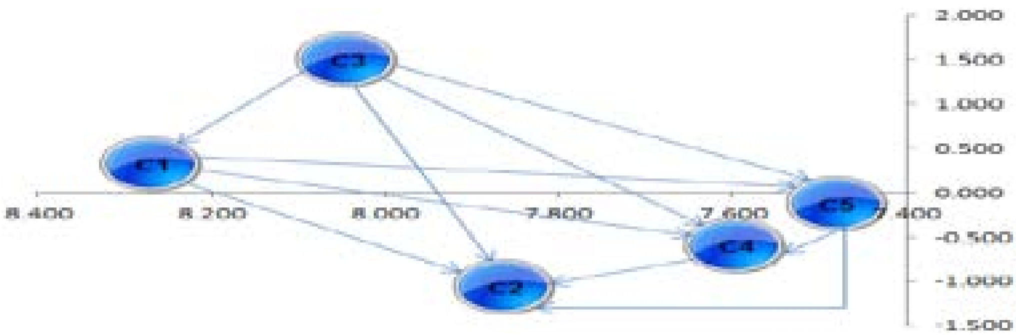


Figure 5. Descartes coordinate system of DEMATEL output for the main criteria

The comparison and determining the priority of sub-criteria

In the third step, the study sub-criteria were compared as paired. In this step, the pair-wise comparisons were done in five stages. In each stage, the sub-criteria of each main criterion of business intelligence evaluation were compared as paired. Based on the fuzzy calculations, the fuzzy pair-wise comparison tables were as following:

Table 12. Pair-wise comparison matrix of the business and users needs

S12	S11	
(3.24, 3.45, 3.65)	(1, 1, 1)	S11
(1, 1, 1)	(0.27, 0.29, 0.31)	S12

Table 13. Pair-wise comparison matrix of business intelligence system function

S24	S23	S22	S21	
(3.3, 4, 4.7)	(0.48, 0.64, 0.87)	(0.7, 0.83, 0.98)	(1, 1, 1)	S21
(2.9, 3.8, 4.7)	(0.63, 0.77, 0.94)	(1, 1, 1)	(1.02, 1.21, 1.43)	S22
(5.7, 6.4, 7.1)	(1, 1, 1)	(1.06, 1.3, 1.59)	(1.15, 1.57, 2.09)	S23
(1, 1, 1)	(0.14, 0.16, 0.18)	(0.21, 0.26, 0.34)	(0.21, 0.25, 0.3)	S24

Table 14. Pair-wise comparison matrix of system flexibility

S33	S32	S31	
(1.76, 2.07, 2.39)	(2.89, 3.12, 3.4)	(1, 1, 1)	S31
(3.72, 4.23, 4.73)	(1, 1, 1)	(0.29, 0.32, 0.35)	S32
(1, 1, 1)	(0.21, 0.24, 0.27)	(0.42, 0.48, 0.57)	S33

Table 15. Pair-wise comparison matrix of meeting the organization regulations

S43	S42	S41	
(1.43, 1.69, 1.96)	(1.47, 1.49, 1.53)	(1, 1, 1)	S41
(3.65, 3.78, 3.92)	(1, 1, 1)	(0.66, 0.67, 0.68)	S42
(1, 1, 1)	(0.26, 0.26, 0.27)	(0.51, 0.59, 0.7)	S43

Table 16. Fuzzificated pair-wise comparison matrix of organization regulations

S52	S51	
(4.9, 5.02, 5.13)	(1, 1, 1)	S51
(1, 1, 1)	(0.19, 0.2, 0.2)	S52

The defuzzificated prioritization of the indices of five elements of business intelligence evaluation is as:

Vector 3- Vector W32

$$W_{32}=\begin{pmatrix} 0.618 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.382 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.134 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.241 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.357 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.268 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.390 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.329 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.281 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.204 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.430 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.366 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.659 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.341 \end{pmatrix}$$

Determining the final priority of the indices

Finally, to achieve the general priorities of defuzzificated values are transferred into the super decision software. Based on the study purpose, based on the criteria and sub-criteria, the model of network analysis is designed in super decision software. Thus, based on this model ANP is shown in Figure 6. After the required calculations, finally the general priorities of the indices with fuzzy ANP techniques are presented. The summary of the results of FANP technique is shown in Table 17.

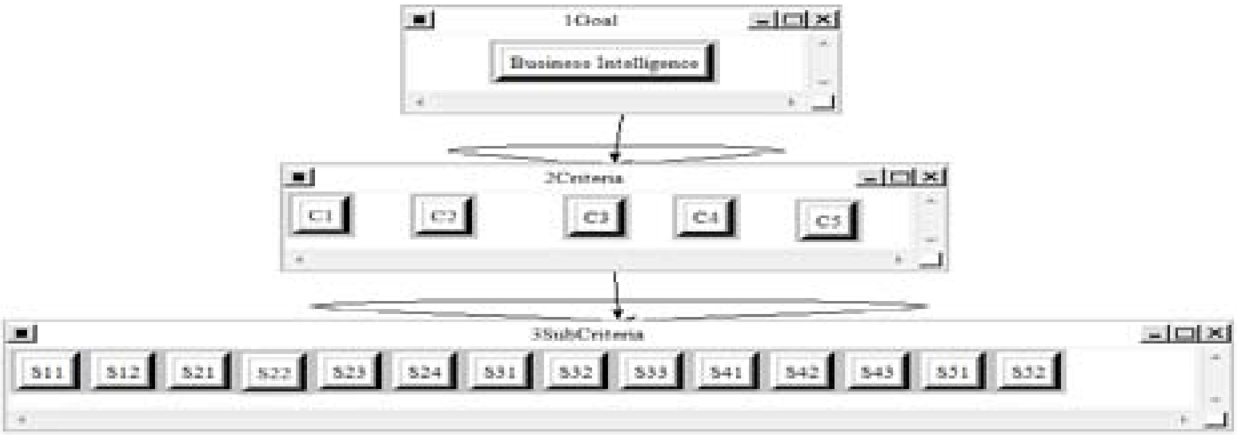


Figure 6. ANP chart of the priority of indices in super decision software

Table 17. The final priority of the indices of model with ANP, FANP

Index	Index	Initial weight	Normal weight
S11	Responding the user's needs	0.514	0.1305
S12	Consistency of the system with the strategic goals	0.498	0.1265
S21	Application simplicity factors and data visualization ability	0.374	0.0949
S22	The accuracy of output data	0.318	0.0806
S23	System security	0.316	0.0801
S24	System response time	0.307	0.0780
S31	Comfort factors of applying changes in the system	0.269	0.0682
S32	Flexibility and parametric nature of the output reports	0.262	0.0664
S33	Future development of the system	0.258	0.0654
S41	Users participation factor	0.242	0.0616
S42	Supporting the organization efficiency	0.182	0.0461
S43	Supporting decision making	0.164	0.0416
S51	The factors of using the application of the experiences	0.146	0.0370
S52	Integration of the information needs of the business performers	0.091	0.0231

Discussion and conclusion

Business intelligence should lead into taking decisions leading into more profitability of business and promotion of the quality of business. Thus, business intelligence can not develop business. Thus, in case of true understanding for the managers, it is harmful and its definition for the job owners should done with accuracy in order not to increase the expectations of entering business intelligence to business. The results of the study in which among the sub-criteria in classic ANP and fuzzy ANP, the sub-criterion of meeting the demands of business and users was highly preferred and the consistency of the system with the strategic goals was in the second priority and the next sub-criteria were in the next priority. The results of the study can give useful information to the decision makers and IT managers in the organizations to have complete recognition to business intelligence dimension to reduce the costs and failure in establishment of this system.

During the study process, it was defined that as network analytic process is having a systematic approach in determining the priorities and evaluation of the goals and criteria and the important degree and criteria weight were determined based on people judgment not as voluntarily and could consider all tangible and intangible criteria in the model. But ANP deals with the formation of pair-wise comparison matrix and the calculation of eigen vector corresponding with each of the pair-wise comparison matrix and then put them in a good position of super matrix. Thus, using this technique in calculation of international relation between the elements among the elements need a lot of pair-wise comparison matrix. This issue leads to the complexity and time-consuming for problem solving. In this limitation, DEMATEL technique can be used. DEMATEL compared to ANP to calculate the internal relation between the elements and components need low pair-wise comparison matrices and by this benefit, DEMATEL method cannot form supermatrix and ANP is recommended to use the benefits of two techniques in further study and the combination of DEMATEL and ANP and applied approaches are used.

Reference

Azoff, M., & Charlesworth, I. (2004). *The New business intelligence*. A European Perspective, Butler Group, White Paper.

Elbashir, M., Collier, P., & Davern, M. (2008). Measuring the effects of business intelligence systems: The relationship between business process and organizational performance. *International Journal of Accounting Informati Systems,* 9(3), 135-15

Ghoshal, S., & Kim, S. K. (1986). Building effective intelligence systems for competitive advantage. *Sloan Management Review, 28*(1), 49–58.

Jalonen, H., & Lonnqvist, A. (2009). Predictive business—fresh initiative or old winein a new bottle. *Management Decision, 47*(10), 1595-1609.

Lin, Y., Tsai, K., Shiang, W., Kuo, T., & Tsai, C. (2009). Research on using ANP to establish a performance assessment model for business intelligence systems. *Expert Systems with Applications, 36,* 4135–4146

Lonnqvist, A., & Pirttimki, V. (2006). The measurement of business intelligence. *Information Systems Management, 23*(1), 32 – 40.

Olszak, M. & Ziemba, E. (2007). Approach to Building and Implementing Business Intelligence System, *Inter-disciplinary Journal of Information, Knowledge and Management, 2.*

Renu, V., & Chandra, A. (2010). Predicting stock returns nifty index: An Application of artificial neural net work international research. *Journal of finance and economics.*

Saaty, T.L. (1996). *Analytical Network Process*. Pittsburgh: RWS Publications.

Sawka.K. (2000). Are We Valuable? *Competitive Intelligence Magazine,* 3(2).

Yurdakul, M., & Iç, Y.T. (2009). Analysis of the benefit generated by using fuzzy numbers in a TOPSIS model developed for machine tool selection problems, *Journal of materials processing technology, 209,* 310–317.