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Performance Evaluation of IT Industries Using SERVQUAL, DEA and FMCDM

Case Study: System Group Company

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Abstract. In developed countries, improvement has been made in service providing industries along with the improvements made in quality assurance and management skills and systems in the domain of manufacturing industries. Unfortunately, in developing countries, primary needs have led these countries to focus their attention illogically and solely on production and they disregard the quality of services. That is why this research aims at investigating service improvement in the domain of Information Technology. Nowadays, the role played by information technology and communication in economic growth is evident to everyone. Because of access to Internet, communication and information technology is considered one of the major elements in providing services and has improved the efficiency of this industry. Meanwhile, focusing on service quality is an efficient approach that results in customer orientation in an organization and is believed by our domestic organizations and companies to be an efficient method to satisfy customers' demands and has been applied so many times. Presenting a compound approach, this research uses

SERVQUAL as a tool for quality engineering of services, and multiple criteria decision making for ranking service providing branches, and data envelopment analysis for making improvement and benchmarking and it is an attempt to overcome these weaknesses and develop quality models in regard with service providing so that the current gap can be filled.

Keywords: Information Technology (IT), Quality of Services (QOS), SERVQUAL, Data Envelopment Analysis (DEA), Fuzzy Multi-Criteria Decision Making (FMCDM).

1. Introduction

In recent years, quality management systems have increasingly been used in our country in various industrial, technical and professional domains. Quality management systems are established and applied with the purpose of developing customer orientation in organizations and community wide. Organizations who run quality management system, has achieved a true understanding about customers' demands and quality requirements (explicit requirements). Moreover, these organizations have tried to identify demands and requirements that are considered evident by customers (implied requirements). To make sure that customers' expectations are met, various skills and methods are formed in the domain of management within the past decades. Using quality engineering and management skills and by forming work teams, an organization is able to use its potential capabilities. Meanwhile, Service Quality Method is an efficient way to actualize customer orientation in an organization and according to our country's leading companies and organization, it is an efficient method that satisfies customer demands and has been applied so many times. As it was mentioned in the beginning, customer orientation and quality engineering skill have been increasingly used in our country in recent years. However, focusing only on production has resulted in service providing domain to be deprived of quality managers and engineers' attention. Therefore this research applies one of the techniques of quality engineering named service quality and combines it with fuzzy logic and multiple criteria decision-making models and data envelopment analysis in an attempt to improve and develop quality models in the domain of services.

2. Literature Review

Service quality is interpreted differently based on customers' expectations and their understanding of how a real service functions (Perceptions). The first group of these techniques performed based on field studies and interview includes designing of a questionnaire to obtain experts' views about quality indexes. To obtain the required data and to answer the questions inserted in the questionnaires, in interview sessions, test takers are asked by an examiner. SERVQUAL tool is one of the usual tools designed to study various aspects of service quality. This tool was introduced by Parasurman, Leitmal and Berry in 1998.(Parasurman, Leitmal & Berry,1988). SERVQUAL includes 22 items which measure 5 aspects of quality in services and these 5 aspects include: Assurances, Empathy, Reliability, Responsibility and Tangible indexes. As to the history of SERVQUAL in service quality studies, it should be said that so many researchers have done so many studies in this regard some of which are mentioned below. Fick and Ritchie used SERVQUAL to measure service quality in tourism industry (Fick & Ritchie, 1991). In 2000, Deng and Chang introduced a multiple criteria fuzzy decision-making model to evaluate bus companies. (Deng & Chang, 2000). Yelda and Shresta presented a multiple criteria approach based on analytic hierarchy Process developed by Saaty in 1980, to select the alternatives exist for stable transportation system in New Delhi. (Yelda & Shresta, 2000). In 2003, Yeh & Kuo, studied a multi criteria fuzzy decision making approach to evaluate service quality in 14 major airports of Asia and Oceania(Yeh&Kuo, 2003). Hensher introduced a service quality index for contracts drawn in bus companies in the same year. (Hensher,2003). Cobert,Lawrence,Cavana & Robert developed service quality tools to evaluate the quality of services provided by Willington News Mills Railways to railway passengers and in 2008 (Cobert, Lawerence, Cavana & Robert, 2007). Nathaniel presented a multiple criteria approach to evaluate quality of services provided to Helnik Railways passengers (Nathaniel, 2008). In another research by Ebolli and Mazzulla, an index which was based on customer orientation was introduced to evaluate service quality in transportation industry. (Ebolli & Mazzulla, 2009)

3. Model and Theory

The VIKOR method provides a maximum group utility for the majority and a minimum of an individual regret for the opponent. This method focuses on ranking and selecting from a set of alternatives in the presence of conflicting criteria. It introduces the multi criteria ranking index based on the particular measure of "closeness" to the "ideal" solution. For this reason we extend the VIKOR method so as to process such data and to provide a more comprehensive evaluation in a fuzzy environment. This method is focused on ranking and selection of a group of alternatives in the presence of a group of criteria. In this method, multi criteria ranking index s are introduced based on the degree of their proximity to the ideal answer. Since some of the decision-making data are not defined and are ambiguous and fuzzy, VIKOR method has been developed in fuzzy environment. For instance, a user may access providers of logistic services from the perspective of several quality aspects. If for instance evaluation criteria include adaptation, price, cost, quality and respect, the user cannot evaluate these indices with definite numbers and these can only be expressed using words. So at first we should transfer the linguistic terms into triangular fuzzy numbers, the linguistic terms can be expressed in corresponding triangular fuzzy numbers as Table 1.

Table 1. Linguistic Terms For The Fuzzy Ratings

Corresponding fuzzy numbers	Lingual variables
(0.0,0.0,0.1)	Very Low (VL)
(0.0, 0.1,0.3)	Low (L)
(0.1,0.3,0.5)	Medium Low (ML)
(0.3,0.5,0.7)	Medium (M)
(0.5,0.7,0.9)	Medium High (MH)
(0.7,0.9,1.0)	High (H)
(0.9,0.9,1.0)	Very High (VH)

If the supports of triangular fuzzy numbers expressing linguistic variables (Tables 1) do not belong to the interval [0, 1] then a scaling is needed to transform them back in this interval. Here, we use a linear scale transformation to have a comparable number. As an example, if we transform the rating of alternatives, we have for benefit attributes:

$$\left.\begin{array}{l} y_j^+ \geq \sup\,(\tilde{y}_{1j}, \tilde{y}_{2j}, \ldots, \tilde{y}_{mj}) \\ y_j^- \leq \inf\,(\tilde{y}_{1j}, \tilde{y}_{2j}, \ldots, \tilde{y}_{mj}) \end{array}\right\} \quad (1)$$

$$\tilde{X}_{ij} = \left(\frac{a_{ij} - y_j^-}{y_j^+ - y_j^-}, \frac{b_{ij} - y_j^-}{y_j^+ - y_j^-}, \frac{c_{ij} - y_j^-}{y_j^+ - y_j^-} \right) \quad (2)$$

$i = 1, 2, \ldots, m \qquad j = 1, 2, \ldots, n$

For cost type attributes:

$$\left.\begin{array}{l} y_j^+ \leq \sup\,(\tilde{y}_{1j}, \tilde{y}_{2j}, \ldots, \tilde{y}_{mj}) \\ y_j^- \geq \inf\,(\tilde{y}_{1j}, \tilde{y}_{2j}, \ldots, \tilde{y}_{mj}) \end{array}\right\} \quad (3)$$

$$\tilde{X}_{ij} = \left(\frac{y_j^+ - c_{ij}}{y_j^- - y_j^+}, \frac{y_j^+ - b_{ij}}{y_j^- - y_j^+}, \frac{y_j^+ - a_{ij}}{y_j^- - y_j^+} \right) \quad (4)$$

$\tilde{y}_{ij} = (a_{ij}, b_{ij}, c_{ij})$

$i = 1, 2, \ldots, m \qquad j = 1, 2, \ldots, n$

$\tilde{S}_j$ and $\tilde{R}_j$ are calculated using equations 5 and 6.

$$\tilde{S}_j = \bigoplus_{i=1}^{m} \tilde{w}_i \; d(1, \tilde{x}_{ij}) \quad (5)$$

$$\tilde{R}_j = \max_i \tilde{w}_i \; d(1, \tilde{x}_{ij}) \quad (6)$$

$i = 1, 2, \ldots, m, \qquad j = 1, 2, \ldots, n$

So that S & R are used for formulating the ranking measure of "group utility" and the "individual regret" respectively. Here, d $(\tilde{1}, r_{ij})$ shows the distance between an alternative rate to positive ideal answer $1 = (1,1,1)$. The maximum amount of $\tilde{w}_i d(\tilde{1}, \tilde{X}_{ij})$ is the one which is most distant from 1 and values of Q_j $(j = 1, \ldots, n)$ are calculated using equation 7.

$$\tilde{Q}_j = \nu \tilde{S}_j{}' \oplus (1-\nu)\tilde{R}_j{}' \quad (7)$$

$$D(F) = \frac{a+2b+c}{4} \quad (8)$$

$j = 1, \dots, n$

Where $\tilde{R}'_j$ & $\tilde{S}'_j$ are forms of $\tilde{R}_j$ and $\tilde{S}_j$, normalized using linear transfer scale. "ν" is the weight of strategy, which is used, in fuzzy VIKOR method.

Order of alternative ranking is determined using formula 8.

First, $\tilde{S}'_j$, $\tilde{R}'_j$, $\tilde{Q}_j$ values are defuzzified into crisp $S'j$, $R'j$, Q_j values. Then, alternatives are ranked by sorting each S'_j, R'_j, Q_j values in an increasing order as in the original VIKOR model. The result is a set of three ranking lists. The alternative $j1$ corresponding to $Q[1]$ (the smallest among Q_j values) is proposed as a compromise solution if:

C1: alternative J1 has one acceptable advantage. In other words,

$Q_{[2]} - Q_{[1]} \geq DQ$ so that $DQ = 1/(m-1)$ and m refers to the number of alternatives.

C2: alternative J1 is stable within the decision making process, in other words it is also the best ranked in $S_{[0]}$ or $R_{[0]}$. If one of the above conditions is not satisfied, then a set of compromise solutions is proposed which consists of:

- Alternative $j1$ and $j2$ where $Q_{j2} = Q_{[2]}$ if only the condition C2 is not satisfied, or
- The alternatives $j1, j2, \dots, jk$ if the condition C1 is not satisfied; and jk is determined by the relation $Q_{[k]} - Q_{[1]} < DQ$ for the maximum k where $Q_{jk} = Q_{[k]}$ (the positions of these alternatives are in closeness).

Efficiency is a concept that conveys how an organization uses its resources to achieve an optimum production. Efficiency can be defined with regard to input and through comparing resources expected to be consumed to resources consumed for a certain purpose. Alternatively, it can be defined with regard to output and through comparing the expected output, to standard output and real output. Efficiency also can be defined based on the input and output of a unit, through calculating the ratio of weighted sum of outputs over weighted sum of inputs. In fact, efficiency is a managerial concept, which has a long history in management science. These definitions are preliminaries to define Data Envelopment Analysis, which is a technique to study efficiency of decision-making units. Data Envelopment Analysis is a linear planning model that calculates relative efficiency of decision-making units that have several inputs and outputs. After introduction of Data Envelopment Analysis by (Charnes,1978) this method developed continuously and rapidly so that now after 30 years, applied researches are being conducted in this branch of operational research at a higher rate and volume. Data Envelopment Analysis is a method used to calculated relative efficiency of decision-making units like banks, hospitals, universities, each of which receives several inputs and produces several outputs. The key specification of this method is that decision-making units are under congruent studies and use similar inputs to produce similar outputs. This is the same feature that makes units comparable. DEA is a non-parametric approach that does not require any assumptions about the functional form of a production function and a priori information on importance of inputs and outputs. The relative efficiency of a DMU is measured by estimating the ratio of weighted outputs to weighted inputs and comparing it with other DMUs. DEA allows each DMU to choose the weights of inputs and outputs which maximize its efficiency. The DMUs that achieve 100%efficiency are considered efficient while the other DMUs with efficiency scores below 100% are inefficient. For every inefficient DMU, DEA identifies a set of corresponding efficient DMUs called a reference set that can be used as benchmarks for improvement. DEA also allows for calculating the required amount of improvements in the inefficient DMU's inputs and outputs to make it efficient. The first DEA model proposed by Charnes is the CCR model that assumes that production exhibits constant returns to scale. Banker extended it to the BCC model for the case of variable returns to scale. DEA models are also distinguished by the objective of a model: maximize outputs (output-oriented) or minimize inputs (input-oriented). The output-oriented BCC model employed in this study is formulated as

$$\begin{aligned} \text{Max} \quad & \eta \\ \text{s.t.} \quad & X\lambda \leq X_0 \\ & \eta\, Y_0 - Y\lambda \leq 0 \\ & e\lambda = 1 \\ & \lambda \geq 0 \end{aligned} \qquad (9)$$

where X is the matrix of input vectors, Y is the matrix of output vectors, (xo, yo) is the DMU being measured, η is the reverse of the efficiency score, λ is the vector of intensity variables. The only difference between the CCR and BCC model is the presence of the convexity condition. While DEA was originally developed for measuring efficiency of multiple units performing a transformation process of several inputs and several outputs, DEA is now playing a broader role, as a tool for multiple criteria decision making (MCDM) problems. Despite the fact that the traditional goals of DEA and MCDM differ in that MCDM aims to prioritize a set of alternatives having conflicting criteria, many researchers have found similarities between DEA and MCDM. It has been recognized that the MCDM and DEA formulations coincide if inputs and outputs are viewed as criteria, with minimization of inputs and maximization of outputs.Such criteria can be divided into two types: costs or negative (the smaller the value, the better), evaluation items as inputs and benefits or positive (the greater the value, the better) evaluation items as outputs. Then, efficiency scores of DMUs are considered as priority weights or performance scores of MCDM. When this is the case, it is not assumed that inputs are necessarily and directly transformed into outputs. In some MCDM problems, there is no negative (or positive) evaluation item. In other words, all criteria are preferred to be high (or low); thus, only outputs (or inputs) exist when using DEA. To accommodate this kind of situations, Lovell and Pastor suggested the pure output (or input) model without inputs (or outputs). They proved that an output-oriented CCR model with a single constant input and an input-oriented CCR model with a single constant output coincide with the corresponding BCC models, but a CCR model without inputs (or without outputs) is meaningless. The pure output model has successfully been employed in various problems such as target setting of bank services, facility layout design, and service process benchmarking. This study also adopts the pure output model for aggregating the scores of the five dimensions of SERVQUAL into a single measure of service quality since all dimensions are positive items. They demonstrate that (i) a CCR model without input (or without output) is meaningless; (ii) a CCR model with a single constant input (or with a single constant output) coincide with the corresponding BCC model;(iii) a BCC model with a single constant input (or a single constant output) collapses to a BCC model without inputs(or without outputs);and (iv) all BCC models, including those without inputs (or without outputs), can be condensed to models having one less variable (the radial efficiency score) and one less constraint (the convexity constraint). A pure output model is applied successfully in so many models like bank services goal setting, arranging equipment, and benchmarking service process. In this research pure output model has been used to merge the points relating to 5 aspects of SERVQUAL with a service quality value when all aspects of the item are positive. SERVQUAL is a multiple-item scale composed of 5 dimensions and 22 items for measuring consumer perceptions of service quality. Table I presents the five dimensions of SERVQUAL. The survey instruments for SERVQUAL of include the 22 items for measuring expectations (E) and the corresponding 22 items for measuring perceptions (P). Five or seven point Likert scale from “Strongly Disagree (1)” to “Strongly Agree (7)” can be used for measurement. For each item, a difference score Q is obtained as the difference between the ratings on perception (P) and expectation (E); that is, $Q = P - E$ Taking the two advantages of DEA, usefulness for benchmarking and applicability to MCDM, this study proposes a DEA-based approach to measuring and benchmarking of service quality. Measuring the overall quality of service units with SERVQUAL can be viewed as a MCDM problem in which the five criteria are employed for measuring the performance of the units in terms of service quality. In addition, DEA can be used as a tool for MCDM by considering input/output variables of DMUs as negative/positive criteria for evaluation of alternatives. Thus, DEA is capable of aggregating the scores of the five dimensions of SERVQUAL into a single measure of service quality. Companies do specialized activities and some other attends various geographical areas to provide customers of these areas with their services.

4. Illustrative Example

In this part, a numerical instance of real data regarding System Group CO. (the largest software production company in Iran) is presented. Tables 1 to 5 provides you with problem solving steps using fuzzy VIKOR method, data normalization, and ranking service providing branches. Next through Data Envelopment Analysis, reference-set decision-making units are identified for benchmarking.

1. Specifications of Services provided to establish Integrated Information Management System

1-1-Understanding the situation
- 1-1-1-Holding general sessions before project execution
- 1-1-2-Receiving recognition plan certificate
- 1-1-3-Special meetings of the director's circles

1-2-Process designing
- 1-2-1-Presenting successful executive models in similar industries
- 1-2-2-Expert's sufficient knowledge regarding the process
- 1-2-3-Considering special organizational processes
- 1-2-4-Designing processes having future development as a perspective

1-3-Making software proper for use
- 1-3-1-Developing executive modules for special processes
- 1-3-2-Possibility of adding other software systems
- 1-3-3-Preparing special reports required by the organization
- 1-3-4-Presenting pamphlet and other educational notes.

1-4-Educating users
- 1-4-1-Possibility of entering test information in educational copy
- 1-4-2-Presenting executive models in similar industries
- 1-4-3-Making educational activities proper for various knowledge levels
- 1-4-4-Using useful opinions of users
- 1-4-5-Increasing number of practical education sessions
- 1-4-6-Experts with pertinent document and sufficient experience
- 1-4-7-Accessibility of experts in times other than working hours
- 1-4-8-Presenting course completion certificate
- 1-4-9-Preparing new reports by users

1-5-connecting to other systems
- 1-5-1-Linking to other Microsoft facilities
- 1-5-2-Connecting to other existing systems

Diagram 1: classification of the five aspects of SERVQUAL tool in IT industry

The alternative with the least S, R, and Q is the best alternative. Considering measures of S, R, and Q, it can be observed that Qazvin branch is privileged to Tehran branch as far as service providing and ranking are concerned.

Table 2. Average weight gain fuzzy numbers extracted from Table 1 and parameters used in the method of fuzzy VIKOR

	Qazvin	Tehran
Sj	0.254	0.269
Rj	0.122	0.136
Qj	0.223	0.293

It should be noted that the input of decision-making units is set at ‘1’ as a default. The model has been applied to 20 service providing organizations and the benchmarking table has been used to achieve efficiency in some service providing units. The model has been applied taking the theory of Lovell and Pastor into account and applying CCR approach. (Lovell & Pastor, 1998)

CCR ; Max Φ_0

$\underset{D}{oo}$

s.t.

$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}$

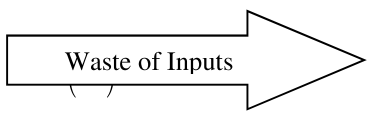
$\sum_{j=1}^{n} \lambda_j x_{ij} + S_i^{-} = x_{i0};\ i$

$\sum_{j=1}^{n} \lambda_j^{*} x_{ij} = x_{i0} + S_i^{-*};\quad i$

$\sum_{j=1}^{n} \lambda_j y_{rj} \geq \Phi_0 y_{ro} \qquad \sum \lambda_j y_{rj} - S_r^{+} = \Phi_0 y_{ro};\ r$

$\sum_{j=1}^{n} \lambda_j^{*} y_{rj} = \Phi_0^{*} y_{ro} + S_r^{+*};\quad r$

$\lambda_j \geq 0 \quad S_i^{-} \geq 0 \quad S_r^{+} \geq 0; \qquad j, i, r$



$\Phi_{0\ Free}$

$i = 1, \ldots, m \qquad j = 1, \ldots, n \qquad r = 1, \ldots, s$

CCR output-oriented DEA model is based on the constraints of equation 10, TRGT in DMU8 is an example, which is one of the decision service units (DMU), according to equation 10, was calculated. To calculate the loss to the shortage of inputs and outputs it should be noted that of course the model has created no more waste as inputs to the definition of the ideal input "1" only the lack of output is calculated.

5. Conclusion

As it was observed, considering the values achieved from the solved Data Envelopment Analysis Model of Lovell and Pastor, since service providing units 7 and 17 are considered as reference sets for decision making unit 8, hence, the improvement goals are achieved through the said equations and the amount of improvement required is achieved through subtracting goal setting indexes from the same index in the pertinent service unit.

This article presents an approach to calculate total service quality value using Data Envelopment Analysis, to allow evaluation and benchmarking when 5 aspects of SERVQUAL are used to evaluate quality. Data Envelopment Analysis is used as a multi criteria decision making technique as far as evaluation of service providing units using SERVQUAL is concerned. In this research, pure output oriented model has been considered without any input. The current model faces some limitations when benchmarking service quality with SERVQUAL. For instance, no guidance or certain criterion exists to determine the amount of service quality to be improved. This research has been performed on measuring and benchmarking service quality with the purpose of overcoming these limitations. This research is conditioned to some limitations that should be taken into account in future researches. First, a set of real data have been used to describe the pertinent approach, hence, a real case study is required to provide real findings with regard to all service providing branches and all customers so that ranking can happen in all branches. Secondly, rates of SERVQUAL data are usually ordinal. Basically, standard data envelopment analysis models are able to work with cardinal data. In many data envelopment analyses, ordinal or quality output or inputs are presented in the form of quantities to enter data envelopment analysis easily. This can be performed in a nominal way. To solve this problem, several solutions are used to systemize ordinal data, like imprecise models (Cooper, 1999) and project model (Cook, 2006). Applying these methods, it seems that we can display the results more properly. The next approach is the measurement of each aspect of SERVQUAL using a ratio scale. This can be performed in future researches.

References

[1] Banker RD, Charnes A, Cooper WW. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Manage Sci* (1984);30;1078-92.

[2] Bouyssou D. Using DEA as a tool for MCDM: *some remarks. J Oper Res Soc* (1999);50;974-8.

[3] Cavana Robert, Y., Corbett Lawrence, M., & Lo, Y. L. (2007). Developing zones of tolerance for managing passenger rail service quality. *International Journal of Quality & Reliability Management*, 24(1), 7–31.

[4] Belton V, Vickers SP. Demystifying DEA: A visual interactive approach based on multi criteria analysis. *J Oper ResSoc*(1993);44;883-96.

[5] Cooper WW, Park KS, Yu G. IDEA and AR-IDEA: models for dealing with imprecise data in DEA. *Manage Sci*(1999);45;597-607.

[6] Charnes A, Cooper WW, Rhodes E. Measuring efficiency of decision making units. *Eur J Oper Res*(1978);2;429-44.

[7] Cook WD, Zhu J. Rank order data in DEA: a general framework. Eur J Oper Res(2006);174;1021-38.

[8] Doyle J and Green R. Data envelopment analysis and multiple criteria decision making. *Omega*(1993);21;713-5.

[9] Eboli, L., & Mazzulla, G. (2008). A stated preference experiment for measuring service quality in public transport. *Transportation Planning and Technology*,31(5), 509–523.

[10] Fick, G. R., & Ritchie, J. R. B. (1991). Measuring service quality in the travel and tourism industry. *Journal of Travel Research, Fall*, 2–9.

[11] Hensher, D. A., Stopher, P., & Bullock, P. (2003). Service quality-developing a service quality index in the provision of commercial bus

contracts. *Transportation Research Part A: Policy and Practice*, 37(6), 499–517.

[12] Lovell CAK, Pastor JT. Target setting: An application to a bank branch network. *Eur J Oper Res*(1997);98;290-9.

[13] Lovell CAK, Pastor JT. Radial DEA models without inputs or without outputs. *Eur J Oper Res* 1999;118;46-51.

[14] Nathanail, E. (2008). Measuring the quality of service for passengers on the Hellenic railways. *Transportation Research Part A: Policy and Practice*, 42(1), 48–66.

[15] Opricovic S,Multicriteria Optimization of Civil Engineering Systems, Faculty of Civil Engineering, Belgrade. 1998

[16] Parasuraman A, Zeithaml VA, Berry LL. SERVQUAL: A multiple item scale for measuring consumer perceptions of service quality*. J Retailing*(1988);65;12-40.

[17] Ramanathan R. Data envelopment analysis for weight derivation and aggregation in the analytic hierarchy process. *Com Oper Res*(2006);33;1289-307.

[18] Saaty, T. L. (1980). The analytic hierarchy process. New York: McGraw-Hill.

[19] Stewart TJ. Relationships between data envelopment analysis and multicriteria decision analysis. *J Oper Res Soc*(1996);47;654-65.

[20] Seol H, Choi J, Park G, Park Y. A framework for benchmarking service process using data envelopment analysis and decision tree*. Expert Syst Appl*(2007);32;432-40.

[21] Yeh, C. H., Deng, H., & Chang, Y. H. (2000). Fuzzy multicriteria analysis for performance evaluation of bus companies. *European Journal of Operational Research*, 126(3), 459–473.

[22] Yedla, S., & Shrestha, R. M. (2003). Multi-criteria approach for the selection of alternative options for environmentally sustainable transport system in Delhi. *Transportation Research Part A: Policy and Practice, 37(8), 717–729.*

[23] Yang T, Kuo C. A hierarchical AHP/DEA methodology for the facilities layout design problem. *Eur J Oper Res(2003);147;128-36.*

6. Appendixes

Table 3. Average weight gain fuzzy numbers extracted from Table 2 and parameters used in the method of fuzzy VIKOR

	Weighted Index	Average
	Wi	Fuzzy Number
Holding general sessions before project execution	0.799	(0.65,0.81,0.905)
Receiving recognition plan certificate	0.779	(0.63,0.79,0.885)
Special meetings of the directors circles	0.673	(0.515,0.68,0.805)
Presenting successful executive models in similar industries	0.642	(0.45,0.645,0.82)
Expert's sufficient knowledge regarding the process	0.736	(0.56,0.745,0.875)
Considering special organizational processes	0.488	(0.315,0.49,0.655)
Designing processes having future development as a perspective	0.636	(0.465,0.64,0.79)
Developing executive modules for special processes	0.487	(0.305,0.485,0.675)
Possibility of adding other software systems	0.499	(0.3,0.5,0.695)
Preparing special reports required by the organization	0.868	(0.73,0.88,0.955)
Presenting pamphlet and other educational notes	0.659	(0.485,0.665,0.81)
Possibility of entering test information in educational copy	0.530	(0.33,0.53,0.73)
Presenting executive models in similar industries	0.701	(0.51,0.705,0.875)
Making educational activities proper for various knowledge level	0.660	(0.48,0.665,0.82)
Using useful opinions of users	0.476	(0.33,0.475,0.625)
Increasing number of practical education sessions	0.834	(0.67,0.845,0.955)
Experts with pertinent document and sufficient experience	0.714	(0.52,0.72,0.885)
Accessibility of experts in times other than working hours	0.583	(0.4,0.585,0.76)
Presenting course completion certificate	0.594	(0.4,0.595,0.785)
Preparing new reports by users	0.423	(0.255,0.42,0.605)
Connecting to other existing systems	0.476	(0.33,0.475,0.625)
Linking to other Microsoft facilities	0.642	(0.45,0.645,0.82)

Table 4. Data Envelopment Analysis and its results

	Tangibles	Reliability	Responsiveness	Assurances	Empathy	Efficiency Score	Reference Group
DMU1	2.9	1.6	2.6	4.4	3.3	95	7,14
DMU2	3.8	0.1	3.4	5.2	1.8	100	
DMU3	2.5	0.1	1.2	1.0	2.3	54	6,17
DMU4	0.1	1.9	2.1	3.5	1.1	58	1,6,19
DMU5	2.5	2.7	3.5	2.9	2.6	100	
DMU6	1.5	3.9	2.7	4.9	2.5	100	
DMU7	3.2	0.7	3.2	1.9	3.8	100	
DMU8	1.8	2.8	1.5	4.1	2.6	88	7,17
DMU17	3.9	2.6	4.4	5.1	4.5	100	

Table 5. model of decision making (for example DMU8) and target setting for Benchmarking

		Tangibles	Reliability	Responsiveness	Assurances	Empathy
1	DMU 7	3.2	0.7	3.2	1.9	3.8
2	DMU 17	3.9	2.6	4.4	5.1	4.5
3	Improvement target	4.7	5.6	5.3	4.7	5.1
4	DMU 8	1.8	2.8	1.5	4.1	2.6
5	Improvement required	2.9	2.8	3.8	0.6	2.5