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Applying Fuzzy Decision Making Approach to IT Outsourcing Supplier Selection

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Abstract—The decision of information technology (IT) outsourcing requires close attention to the evaluation of supplier selection process because the selection decision involves conflicting multiple criteria and is replete with complex decision making problems. Selecting the most appropriate suppliers is considered an important strategic decision that may impact the performance of outsourcing engagements. The objective of this paper is to aid decision makers to evaluate and assess possible IT outsourcing suppliers. An axiomatic design based fuzzy group decision making is adopted to evaluate supplier alternatives. Finally, a case study is given to demonstrate the potential of the methodology.

Keywords—IT outsourcing, Supplier selection, Multi-criteria decision making, Axiomatic design, Fuzzy logic.

I. Introduction

INDUSTRIAL organizations are constantly in search of new solutions and strategies to develop and increase their competitive advantage. Outsourcing is one of these strategies that can lead to greater competitiveness [1, 2]. Briefly, it can be defined as a managed process of transferring activities to be performed by others. Information technology (IT) outsourcing means that the physical and/or human resources related to an organization's information technologies (ITs) are supplied and/or administered by an external specialized provider. IT outsourcing is often more efficient than developing systems internally because production costs are lower with outsourcing. The provider obtains scale economies from mass-producing its services and distributing its fixed costs among a great number of end-user clients [3]. Outsourcing IT can include data centers, wide area networks, applications development and maintenance functions, end-user computing and business processing [4].

There are numerous reports of the increasing use of IT outsourcing and several authors have indicated that in many industry areas IT outsourcing has become a rapidly expanding source of competitive advantage [3, 5, 6, 7, 8, 9, 10].

Two themes in the IT outsourcing research have attracted interest among the researchers: (1) the reasons for, the benefits and risks of outsourcing decision (make or buy), (2) the selection of a partner for the outsourcing relationship. This study focuses on the latter.

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Analytical models for supplier evaluation range from simple weighted scoring models to complex mathematical programming approaches. The most common approaches and methods for supplier selection include different multi criteria decision-making (MCDM) methods such as analytic hierarchy process [11] and analytic network process [12], statistical techniques such as principal components analysis and factor analysis [13], data analysis techniques such as cluster analysis, discriminant analysis, data envelopment analysis [14] and simulation [15].

The decision for the determination and selection of strategic suppliers poses a multiple criteria problem. The goal of the multiple criteria decision-making (MCDM) method is to aid decision-makers in integrating objective measurements with value judgments that are based not on individual opinions but on collective group ideas [16].

Axiomatic design (AD) principles [17] including the information axiom (IA) presents an opportunity for MCDM. In the literature, there are many applications of AD methodology to design, products, systems, organizations and software [18]. AD principles provide a powerful tool to measure how well system capabilities respond to functional requirements (FRs). AD consists of two axioms; one of them is the independence axiom and the other is IA. The IA proposes the selection of proper alternative that has minimum information content. Further, there are situations in which information is incomplete or imprecise or views that are subjective or endowed with linguistic characteristics creating a ''fuzzy'' decision making environment. In addition, multiple DMs are often preferred rather than a single DM to avoid the bias and to minimize the partiality in the decision process [19]. For this reason, a Fuzzy Axiomatic Design (FAD) based group decision making approach is applied in order to strengthen the IT outsourcing supplier selection process.

The paper is organized as follows. Section 2 describes the details of the proposed evaluation framework. To validate our model and to examine its effectiveness, a case study is given in Section 3. Last section includes some concluding remarks.

II. Methodology

Firms seek to capitalize on and increase their capabilities and endowments, and interfirm cooperation allows firms to share resources and, thereby, overcome resource-based constraint to growth [20]. Recent studies have focused on the capability of partnerships to create significant competitive advantages in a complex environment. Having a long-term relationship with a well-chosen supplier can reduce the cost of material and improve corporate competitiveness. Many research results have indicated that the decision involved in selecting suppliers becomes the most important activity of an outsourcing process [21, 22, 23]. In the management of IT outsourcing activities, supplier selection decisions are an important component of the IT outsourcing process, where the firm has to choose between a number of distinct IT suppliers [24, 25].

Main steps of the proposed methodology are recapitulated in Figure 1. The first step in the methodology is identifying the IT outsourcing supplier evaluation criteria that are considered the most important. Then, supplier alternatives to be evaluated are designated. According to FRs and selected alternatives, the group of experts determines two groups of range in linguistic terms: design range, i.e., the range of FRs and system range, i.e., alternatives' performances. Afterwards, linguistic terms are translated into fuzzy numbers and criteria weights are determined by using a fuzzy MCDM technique, namely fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution). Expert judgments are aggregated and information contents and weighted information contents for each alternative according to each FR are calculated. The last step of FAD methodology is ranking the alternatives and selecting the best one according to a decreasing order of information content. Finally, the FAD methodology results are justified with fuzzy TOPSIS methodology.

Step 1. Determining evaluation criteria
Step 2. Determining the alternatives
Step 3. Determining design and system ranges (FRs)
Step 4. Translating linguistic terms into fuzzy numbers
Step 5. Aggregating expert opinions
Step 6. Determining criteria weights
Step 7.Calculating information contents
Step 8.Calculating weighted information contents
Step 9.Ranking the alternatives
Step 10. Justifying the result with fuzzy TOPSIS

Fig. 1. Main steps of the proposed methodology

2.1. IT outsourcing supplier evaluation criteria

The purpose of IT outsourcing supplier selection is to determine the optimal service provider who offers the best all-around package of products and services for the customer. A set of evaluation criteria has to be defined prior to evaluate prospective IT suppliers that have compatible goals, appropriate skills, effective motivation, and complementary strategic orientations. This is because managers must find ways to develop win-win deals (both partners benefit) for this outsourcing to be successful. Thus, it is critical for managers to identify and understand effective supplier selection criteria prior to entering into strategic outsourcing. One of the first to systematically conduct an in-depth study of IT supplier selection criteria was Halvey and Melby [26]. Based on a detailed literature survey (such as [5, 7, 10, 22, 23, 26, 27]), six main evaluation criteria are determined and used in our proposed framework. These are:

C_1 – Technological capability
C_2 – Profitability of supplier
C_3 – Relationship closeness
C_4 – Total cost
C_5 – Service quality
C_6 – Reputation of supplier

2.2. Fuzzy axiomatic design approach

In the literature, while there are many applications of AD methodology [17, 18], there are a relatively few studies on FAD applications for MCDM. Kahraman and Kulak use FAD approach for both multi-attribute transportation company selection under determined criteria [28] and the comparison of advanced manufacturing systems [29]. Kulak [30] developed a decision support system based on the FAD. Recently, Celik et al. [31] applied it for shipyard selection.

FAD methodology is based on the conventional AD that was initiated by Suh [17]. The basic idea of AD lies in calculating the intersection of design requirements with the specifications that the system provides (design and system ranges). Figure 2 illustrates the design and system ranges as well as the common area in a non-fuzzy environment.

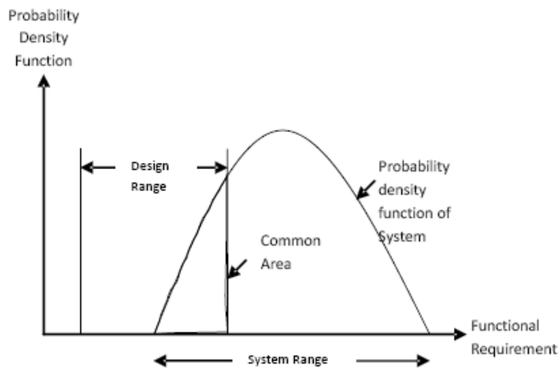

Fig. 2. System-Design ranges and common area

Information context is calculated as (1) in a non-fuzzy environment. In FAD, this basic idea remains the same while crisp ranges are now triangular fuzzy numbers (TFNs). As shown in Figure 3, the common area is the intersection of two triangles.

$$I_i = \log_2\left(\frac{system\ range}{common\ area}\right) \tag{1}$$

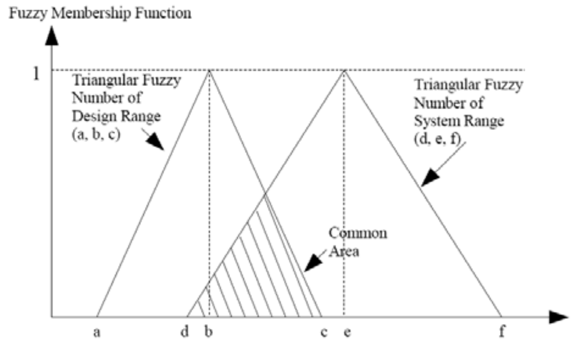

Fig. 3. System-Design ranges and common area in fuzzy environment

Information content is calculated as the area of TFN of system range divided by the common area. Information content is in the logarithmic scale in order to give additive characteristic. I_{ij} is the information content of the alternative i in respect to criterion j. By the second axiom of AD, the design with the smallest information content is the best design. Total information content I_{TOTi} is calculated as the sum of all information contents for alternative i.

$$I_{ij} = \log_2\left(\frac{TFN \quad of \quad System \quad Range}{Common \quad Area}\right) \tag{2}$$

After calculating the I_{TOT}, weighted information content WI_{TOT} is calculated as:

$$WI_{ij} = (I_{ij})^{w_j} \tag{3}$$

w_j represents the weight of criterion j.

2.3. Fuzzy TOPSIS technique

In our methodology, another MCDM method is required to determine evaluation criteria weights. Fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is applied due to its basic concept and wide applications [32, 33].

With m alternatives, n criteria and k decision makers, fuzzy MCDM problem can be expressed as:

$$\tilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \ldots & \tilde{x}_{1n} \\ \vdots & \ddots & & \\ \vdots & & \ddots & \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \ldots & \tilde{x}_{mn} \end{bmatrix} \end{array} \tag{4}$$

In (4), D represents the fuzzy decision matrix with alternatives A and criteria C. Aggregated judgments $\tilde{x}_{ij}$ are calculated as follows:

$$\tilde{x}_{ij} = \frac{1}{k}(\tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + \ldots + \tilde{x}_{ij}^k) \tag{5}$$

$$\tilde{x}_{ij}^k = (\tilde{a}_{ij}^k, \tilde{b}_{ij}^k, \tilde{c}_{ij}^k) \tag{6}$$

In (5), $\tilde{x}_{ij}^k$ represents fuzzy judgment of expert k. The next step is the normalization. Normalized fuzzy decision matrix $\tilde{R}$ is calculated as:

$$\tilde{R} = \left[\tilde{r}_{ij}\right]_{m*n}, i = 1,2\ldots,m; j = 1,2\ldots n \tag{7}$$

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{C_j^+}, \frac{b_{ij}}{C_j^+}, \frac{c_{ij}}{C_j^+}\right) \tag{8}$$

$$C_j^+ = \max_i C_{ij} \tag{9}$$

Then, weighted normalized fuzzy decision matrix is computed with the weights calculated in FAD technique, where w_j is weight for criteria j.

$$\tilde{v} = \left[\tilde{v}_{ij}\right]_{m*n}, i = 1,2\ldots,m; j = 1,2\ldots n \tag{10}$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j \tag{11}$$

Since the TFNs are included in [0,1] range, positive and negative ideal reference points (FPIRP, FNIRP) are as follows:

$$A^+ = \left\{\tilde{v}_1^+, \tilde{v}_2^+, \ldots \tilde{v}_n^+\right\}, A^- = \left\{\tilde{v}_1^-, \tilde{v}_2^-, \ldots \tilde{v}_n^-\right\} \tag{12}$$

$$\tilde{v}_j^+ = (1,1,1), \tilde{v}_j^- = (0,0,0) \tag{13}$$

The next step is calculating the distance of alternatives from FPIRP and FNIRP.

$$d_i^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^+), i = 1,2\ldots m; j = 1,2\ldots n \tag{14}$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-), i = 1,2\ldots m; j = 1,2\ldots n \tag{15}$$

$$d(\tilde{A}, \tilde{B}) = \sqrt{\frac{1}{3}\left[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2\right]} \tag{16}$$

Finally, the performance indices are computed in order to rank the alternatives. Performance indices are sorted in decreasing order.

$$PI_i = \frac{d_i^-}{d_i^- + d_i^+}, i = 1,2\ldots m \tag{17}$$

IV. CASE STUDY

The Company ABC is a well-known Turkish logistics firm. The center of the company is located in İstanbul but it has offices in different places. The Company ABC carried out various national and international logistics activities. The IT department of the ABC has the role of facilitating the technology integration and IT service development towards integrated solutions. This department manages ABC's electronic services and internal information systems. In the beginning of 2009, ABC makes the decision that it should use an external partner for its hosting of IT. Six IT companies that are considered as most important are identified. Due to the confidentiality, we will name those companies as Company A, B, C, D, E and F.

For evaluating the alternatives and FRs in a consistent manner, we have contacted two different expert groups. The first group is composed of three experts. These experts have been selected from logistics industry to evaluate the alternatives. The other group is composed of ABC Company's managers to determine FRs. Finally, ABC Company's IT outsourcing supplier selection process is performed by applying the following steps:

Steps 1-2. Determination of evaluation criteria and alternatives: The determined six evaluation criteria and six alternatives have already been discussed in previous parts.

Step 3. Determination of the design and system ranges and FRs: Linguistic terms employed in evaluating partner alternatives to be translated in fuzzy numbers in order to apply a MCDM method. In this study, 5-level fuzzy scale is used to assess the alternatives and another 5-level fuzzy scale is used to assess the FRs as given in Tables 1 and 2. The group of experts assesses a design range for FRs with the given scale. Table 3 shows the first expert judgments

TABLE I MEMBERSHIP FUNCTIONS FOR SYSTEM RANGE

Term	Abbrv.	Fuzzy Scale
Poor	P	0, 0, 0.3
Fair	F	0.2, 0.35, 0.5
Good	G	0.4, 0.55, 0.7
Very Good	VG	0.6, 0.75, 0.9
Excellent	E	0.8, 1, 1

TABLE II MEMBERSHIP FUNCTIONS FOR DESIGN RANGE

Term	Abbrv.	Fuzzy Scale
At least Poor	LP	0, 1, 1
At least Fair	LF	0.1, 1 1
At least Good	LG	0.4, 1, 1
At least Very Good	LVG	0.6, 1, 1
At least Excellent	LE	0.8, 1, 1

Steps 4-5. Linguistic terms are translated into fuzzy membership functions and expert opinions are aggregated.

TABLE III FIRST EXPERT EVALUATION DATA FOR DESIGN AND SYSTEM RANGES

	Design Range	System Ranges					
		A	B	C	D	E	F
C_1	LG	E	F	VG	F	VG	P
C_2	LVG	E	VG	VG	E	VG	E
C_3	LG	G	E	F	E	E	E
C_4	LG	P	E	F	E	G	E
C_5	LG	VG	VG	VG	E	E	E
C_6	LF	P	P	G	VG	E	VG

Step 6. Determination of criteria weights: With expert judgments on importance of criteria, they are calculated using fuzzy TOPSIS given in Section 2.3. Table 4 displays the criteria weights for evaluating partners.

TABLE IV EVALUATION CRITERIA WEIGHTS

C_1	C_2	C_3	C_4	C_5	C_6
0.21	0.31	0.17	0.17	0.12	0.12

Step 7. Calculation of the information contents (ICs): With aggregated triangular fuzzy numbers of system and design ranges, we use (2) to compute unweighted IC. This step is important in determining the most appropriate partner if all criteria were of equal importance. Table 5 shows IC for each criterion and total IC for each alternative. In respect to second axiom of AD, Company E with the smallest IC is the most appropriate partner.

TABLE V UNWEIGHTED ICS

	I_{C1}	I_{C2}	I_{C3}	I_{C4}	I_{C5}	I_{C6}	I_{TOT}
A	0.04	0.09	1.19	6.31	0.34	2.59	10.57
B	∞	1.54	0.11	0.10	0.33	2.58	∞
C	1.19	1.49	3.69	6.23	0.33	0.59	13.54
D	7.40	0.09	0.02	0.02	0.02	0.17	7.72
E	0.66	1.49	0.11	1.92	0.02	0.003	**4.20**
F	∞	0.07	0.11	0.11	0.02	0.17	∞

Steps 8-9. Calculation of the weighted information contents (WICs) and ranking the alternatives: After calculating the IC, WIC is calculated with (5). Table 6 shows the results for total WIC. Final results demonstrate that Company D is slightly superior to Company E.

TABLE VI WEIGHTED ICS

	WI_{C1}	WI_{C2}	WI_{C3}	WI_{C4}	WI_{C5}	WI_{C6}	WI_{TOT}
A	0,51	0,60	1,03	1,37	0,88	1,12	5,51
B	∞	1,10	0,69	0,68	0,88	1,12	∞
C	1,04	1,09	1,25	1,36	0,87	0,94	6,55
D	1,52	0,61	0,51	0,50	0,62	0,81	**4,57**
E	0,92	1,09	0,69	1,12	0,62	0,51	4,93
F	∞	0,58	0,69	0,69	0,62	0,81	∞

Step 10. To justify the results, we use fuzzy TOPSIS as given in Section 2.3. Table 7 summarizes the final ranking calculated with fuzzy TOPSIS. g with the performance indices of the alternatives. Both techniques conclude that Company D and Company E are the most suitable ones.

TABLE VII FINAL RANKING OF PARTNER ALTERNATIVES WITH FUZZY TOPSIS

Partner alternatives	PI_{TOT}
D	**0,124**
E	**0,123**
F	0,120
B	0,103
A	0,102
C	0,088

IV. CONCLUSION

The process of supplier selection is crucial to success of outsourcing activity and achieves a competitive advantage. For this reason, this study proposed a fuzzy group decision making framework for an effective IT outsourcing supplier evaluation problem. In general, multi criteria problems adhere to uncertain and imprecise data and fuzzy set theory is adequate to deal with case. For this reason, FAD is applied. An empirical case study is used to exemplify the approach. The proposed model is expected to provide additional contributions and decision support to the managers in selecting most appropriate outsourcing suppliers.

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REFERENCES

[1] Embleton, P.R., Wright, P.C. (1998). A practical guide to successful outsourcing. Empowerment in Organizations, 6 (3), 94-106.

[2] Hines, P. and Rich, N. (1998). "Outsourcing competitive advantage: the use of supplier associations", International Journal of Physical Distribution & Logistics Management, 28 (7), 524-546.

[3] Klepper, R., Jones, W.O. (1998). Outsourcing Information Technology Systems and Services. Prentice Hall, New Jersey.

[4] Cullen, S., Seddon, P.B., Willcocks, L.P. (2005). IT outsourcing configuration: Research into defining and designing outsourcing arrangements, Journal of Strategic Information Systems, 14 (4), 357-387.

[5] Cullen, S., Willcocks, L.P. (2003). Intelligent IT Outsourcing: Eight Building Blocks to Success. Elsevier, Chichester.

[6] Dibbern, J., Goles, T., Hirschheim, R., Jayatilaka, B. (2004). Information systems outsourcing: a survey and analysis of the literature. ACM Data Base 35 (4), 6–102.

[7] Lacity, M.C., Willcocks, L.P. (2001). Global IT Outsourcing: In Search of Business Advantage. Wiley, Chichester.

[8] Solli-Sæther, H., Gottschalk, P. (2008). Maturity in IT outsourcing relationships: an exploratory study of client companies. Industrial Management & Data Systems, 108 (5), 635 – 649.

[9] Goo, J., Huang, C.D. (2008). Facilitating relational governance through service level agreements in IT outsourcing: An application of the commitment–trust theory, Decision Support Systems, 46 (1), 216-232.

[10] Venkatraman, N. (1997). Beyond outsourcing: managing IT resources as a value center. Sloan Management Review, 38 (3), 51–64.

[11] Handfield, R., Walton, S.V., Stroufe, R., Melnyk, S.A. (2002). Applying environmental criteria to supplier assessment: a study in the application of the AHP. European Journal of Operational Research, 141 (1), 70-87.

[12] Jharkharia, S., Shankar, R. (2007). Selection of logistics service provider: An analytic network process (ANP) approach. Omega, 35(3), 274-289.

[13] Carr, A.S., Pearson, J.N. (2002). The impact of purchasing and supplier involvement on strategic purchasing and its impact on firm's performance. International Journal of Operations and Production Management, 22 (9), 1032-1055.

[14] Liu, J., Ding, F.Y, Lall, V. (2000). Using data envelopment analysis to compare suppliers for supplier selection and performance improvement. Supply Chain Management: an International Journal, 5 (3), 143-150.

[15] Paisittanand, S., Olson, D.L. (2006). A simulation study of IT outsourcing in the credit card business. European Journal of Operational Research, 175, 1248–1261.

[16] Pomerol, J.-C.. Barba Romero, S. (2000). Multicriterion Decision in Management: Principles and Practice. Kluwer Academic Publishers. Norwell.

[17] Suh, N.P. (1990). The principles of design. New York: Oxford University Press.

[18] Suh, N.P. (2001). Axiomatic design; advances applications. New York: Oxford University Press.

[19] Herrera, F., Herrera-Viedma, E., Chiclana, F. (2001). Multiperson decision-making based on multiplicative preference relations. European Journal of Operational Research, 129, 372–385.

[20] Halawi, L.A., McCarthy, R.V., Aronson, J.E. (2006). Knowledge management and the competitive strategy of the firm. The Learning Organization, 13 (4), 384–397.

[21] Işıklar, G., Alptekin, E., Büyüközkan, G. (2007). Application of a hybrid intelligent decision support model in logistics outsourcing. Computers & Operations Research, 34(12), 3701-3714.

[22] Chen, L.Y., Wang, T-C. (2009). Optimizing partners' choice in IS/IT outsourcing projects: The strategic decision of fuzzy VIKOR. International Journal of Production Economics, Article In Press. Available through www.sciencedirect.com.

[23] Chou, D.C., Chou, A.Y. (2008). Information systems outsourcing life cycle and risks analysis. Computer Standards & Interfaces, Article In Press. Available through www.sciencedirect.com.

[24] Araz, C, Ozkarahan, P.M. (2007). An integrated multicriteria decision-making methodology for outsourcing management, Computers & Operations 34 (12) (2007), 3738–3756.

[25] Xia, W., Wu, Z. (2007). Supplier selection with multiple criteria in volume discount environments, Omega 35 (5), 494–504.

[26] Halvey, J.K., Melby, B.M. (2005). Information Technology Outsourcing Transactions: process, strategies, and contracts. John Wiley & Sons Inc., New Jersey.

[27] Han, H-S., Lee, J-M., Seo, Y-W. (2008). Analyzing the impact of a firm's capability on outsourcing success: A process perspective, Information & Management, 45(1), 31-42.

[28] Kulak, O, Kahraman, C. (2005). Fuzzy multi-attribute selection among transportation companies using axiomatic design and analytic hierarchy process. Information Sciences. 170, 191-210.

[29] Kulak, O., Kahraman, C. (2005). Multi-attribute comparison of advanced manufacturing systems using fuzzy vs. crisp axiomatic design approach. International Journal of Production Economics, 95, 415–424.

[30] Kulak, O. (2005). A decision support system for fuzzy multi-attribute selection of material handling equipments. Expert Systems with Applications, 29, 310–319.

[31] Celik, M, Kahraman, C., Cebi, S., Er, I.D. (2009). Fuzzy axiomatic design-based performance evaluation model for docking facilities in shipbuilding industry: The case of Turkish shipyards. Expert Systems with Applications. 36(1), 599-615.

[32] Qureshi, M.N., Kumar, P., Kumar, D. (2008). 3PL Evaluation and Selection Under a Fuzzy Environment: A Case Study. The Icfai Journal of Supply Chain Management. 5, 38-53.

[33] Shih, H-S. (2008). Incremental analysis for MCDM with an application to group TOPSIS. European Journal of Operational Research, 186, 720–734.