Grey topsis method for supplier selection with litrature and Delphi critaria in an auto company

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Abstract: Selecting and evaluating the right suppliers is imperative for an organization's global marketplace competitiveness. Improper selection and evaluation of potential suppliers can dwarf an organization's supply chain performance. The aim of this study is to present a suitable methodology for the evaluation and slection of suppliers for a firm in Iran. Specifically, the study sought to use the GreyTOPSIS and Delphi methodology to select the most appropriate auto Bumper suppliers of an asembling company in IRAN. In this paper we have considered two methods for selecting supplier selection criteria. The Delphi method was chosen first and second based on litrature we selected critaria. we mix two method findings and select the best supplier. Based on the research findings, the best supplier is supplier2.

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Key words: supply chain, supplier selection, Grey Topsis, Delphi method.

1. Introduction

Supply chain cooperation is a complex process that integrates internal production with external distribution services to end customers. Managers should select the best suppliers to increase the efficiency of supply chain management (Chuang et al, 2013).

In order to maintain a competitive position in the global market, organizations have to follow strategies to achieve shorter lead times, reduced costs and higher quality. Therefore, suppliers play a key role in achieving corporate competitiveness, and as a result of this, selecting the right suppliers is a critical component of these new strategies(Jadidi et al, 2010).

The success of a supply chain is highly dependent on selection of good suppliers. That is why the supplier selection is a very important and multi-criteria problem. Several factors may affect the selection decision of the managers. In this respect, supplier selection problem includes tangible and intangible factors.(Nilay et al, 2011)The rest of the paper is organized as follows.

Section 2 describes Supplier Selection Techniques and identifies the selection criteria for a supplier selection problem. In section 3 Grey TOPSIS is briefly reviewed and described, respectively. Section 4 present application of the integrated model to the supplier selection problem as a real-world case with Grey TOPSIS and Delphi method, respectively. The results of the application are discussed and main findings and contributions are drawn in Section 5.

2. Supplier Selection Techniques and criteria

Supplier selection problem is not a new problem and it has a strong literature history. Many studies have been conducted in this area have used different criteria. The first papers in this field published in early 1950. Since then, much research has been done in this area.

Sanayei et al. (2010) used group decision-making process for supplier selection withVIKOR under fuzzy environment, Amid et al. (2010) proposed weighted max–min model for fuzzy multiobjective supplier selection problem, Lee (2010) proposed a fuzzy supplier selection model with the consideration of benefits, opportunities, costs, and risks, Chang et al. (2010) used fuzzy DEMATEL method for developing supplier selection criteria, Tsai et al. (2010) proposed a dynamic decision approach for supplier selection using ant colony system, Amin et al. (2011) used fuzzy SWOT analysis and fuzzy linear programming for supplier selection and order allocation, Lin et al. (2010) proposed an ERP model for supplier selection, and Liao and Kao (2010) used Taguchi loss function, analytical hierarchy process, and multi-choice goal programming for a supplier selection problem.

Behzadian et al (2012) have a research that review contains 266 scholarly papers from 103 journals since the year 2000 separated into nine application areas that one of them is supply chain area with suplier selection subarea. Studies in this subarea are summarized in Table 1:

Chen (2011) summarizes important criteria for supplier selection from the literature as price, delivery, quality, equipment and capability, geographic location, technical capability, management and organization, industrial reputation, financial situation, historical performance, maintenance service, service attitude, packing ability, production control ability, training ability, procedure legality, employment relations, communication system, mutual negotiation, previous image, business relations, previous sales, guarantee and compensation.

Table 1: supplier selection method and authors

Author (s)	Specific area	techniques
Boran, Genc, Kurt, and Akay (2009)	Selecting the most appropriate supplier	Intuitionistic fuzzy TOPSIS
Bottani and Rizzi (2006)	Selecting the most suitable logistics service provider	Fuzzy TOPSIS
Buyukozkan, Feyzioglu, and Nebol (2008)	Selecting a suitable partner for a strategic alliance in a logistics chain	Fuzzy AHP and fuzzy TOPSIS
Chamodrakas, Alexopoulou, and Martakos (2009)	Customer evaluation in the order acceptance process of suppliers	Fuzzy TOPSIS
Chamodrakas, Leftheriotis, and Martakos (2011)	Evaluating four service providers	Fuzzy TOPSIS and simulation
Chen, Lin, and Huang (2006)	Supplier selection problem	Fuzzy TOPSIS
Dalalah, Hayajneh, and Batieha (2011)	Supplier selection problem	Fuzzy DEMATEL and fuzzy TOPSIS
Deng and Chan (2011)	Supplier selection problem	Fuzzy approach and Dempster Shafer
Fazlollahtabar, Mahdavi, Talebi Ashoori, Kaviani, and Mahdavi-Amiri (2011)	Selecting the best suppliers in the electronics market	AHP, multi-objective nonlinear programming and multiple linear regression model
Hatami-Marbini and Tavana (2011)	Selecting a suitable material supplier for a high-technology manufacturing company	Fuzzy TOPSIS and fuzzy ELECTRE I _
Hsu and Hsu (2008)	Selecting an information technology supplier for outsourcing clinical needs	Delphi method and entropy method
Jolai, Yazdian, Shahanaghi, and Azari-Khojasteh (2011)	Supplier selection and order allocation problem among six automobile mirror suppliers	Multi-objective mixed integer linear programming, goal programming, fuzzy AHP and fuzzy TOPSIS
Kara (2011)	Supplier selection problem in paper production	Two-stage stochastic programming and fuzzy TOPSIS
Kahraman, Ates, Cevik,and Gulbay, (2007a)	E-service provider selection problem	Hierarchical fuzzy TOPSIS
Liao and Kao (2011)	Supplier selection problem in a watch firm	Multi-choice goal programming and fuzzy TOPSIS
Lin, Chen, and Ting (2011)	Supplier selection based on an Enterprise resource planning (ERP) model in electronics firm	ANP and linear programming
Lin, Lee, Chang, and Ting (2008)	Subcontractor selection problem from an engineering corporation	Grey number and Minkowski distance function
Onut, Kara, and Isik (2009a)	Supplier evaluation approach for a telecommunications company	Fuzzy ANP and fuzzy TOPSIS
Roghanian, Rahimi, and Ansari (2010)	Selecting a suitable material supplier to purchase key components for new products	Fuzzy TOPSIS
Shyur and Shih (2006)	Strategic vendor selection problem	Nominal group technique, ANP and modified TOPSIS
Singh and Benyoucef (2011)	Supplier selection for a sealed-bid reverse auction for B2B Industrial purchase	Entropy method and fuzzy TOPSIS
Wang et al. (2011a)	Selecting a suitable supplier for a key component in producing a new product Fractional	programming, quadratic programming, and intervalvalued intuitionistic fuzzy TOPSIS
Zeydan, Colpan, and Cobanoglu (2011)	Evaluating suppliers based on efficiency and effectiveness in a manufacturing factory	Fuzzy AHP, fuzzy TOPSIS and DEA

Dickson (1966) was developed 23 criteria to evaluate suppliers. These factors are:

(1) The net price (including discounts and freight charges) offered by each vendor.

(2) The ability of each vendor to meet quality specifications consistently.

(3) The repair service likely to be given by each vendor.

(4) The ability of each vendor to meet specified delivery schedules.

(5) The geographic location of each vendor.

(6) The financial position and credit rating of each vendor.

(7) The production facilities and capacity of each vendor.

(8) The amount of past business that has been done with each vendor.

(9) The technical capability (including research and development facilities) of each vendor.

(10) The management and organization of each vendor.

(11) The future purchases each vendor will make from your firm.

(12) The communication system (with information on progress data of orders) of each vendor.

(13) The operational controls (including reporting, quality control, and inventory control systems) of each vendor.

(14) The position in the industry (including product leadership and reputation) of each vendor.

(15) The labor relations record of each vendor.

(16) The attitude of each vendor toward your organization.

(17) The desire for your business shown by each vendor.

(18) The warranties and claims policies of each vendor.

(19) The ability of each vendor to meet your packaging requirements for his product.

(20) The impression made by each vendor in personal contacts with you.

(21) The availability of training aids and educational courses in the use of the product of each vendor.

(22) Compliance or liklihood of compliance with your procedures (both bidding and operating) by each vendor.

(23) The performance history of each vendor.

Weber and other researchers reviewed as much as 74 articles which address vendor selection criteria in manufacturing and retail environments (Weber et al., 1991). Their research made use of Dickson’s 23 criteria in ranking and analyzing the various supplier selection criteria that has appeared in the literature in recent times. The researchers discovered that net price, delivery and quality were discussed in 80%, 59% and 54% of the 74 articles reviewed respectively, and that these three criteria were rated as having extreme or considerable importance by Dickson. Moreover, production facilities and capability and technical capability were discussed in 31% and 20% of the articles respectively and were also rated by Dickson as considerable importance. Geographical location was discussed in 22% of the articles and was rated as having average importance. According to the researchers, several criteria (such as warranties and claim policies, communication system, impression, labor relations record, amount of past business, and reciprocal agreements) have received little attention in the last five years. (Asamoah et al, 2012)

Choi and Hartley(1996) distinguished 8 factors in the US auto industry. These factors from their initial list of 26 items in rank are: (a) consistency, (b) reliability, (c) relationship, (d) technological capability, (e) flexibility, (f) price, (g) customer service, and (h) finances (8). As we see that consistency as the most important and finances as the least important factor.

2.1 Identification of necessary factors for supplier selection:

This research was carried out in automotive industry. In decision-making models, one of the most important parts is to determine the criteria and measuring indicators. Selecting criteria and indicators is for this purpose that the important aspects and characteristics of suppliers being measured.

In recent years most of all researchers used some of 23 Dikson's factors to evaluate suppliers. In this research we ranked suppliers in two wayes first with litrature that critaria are extremly or considerable important of dikson or three high used in weber research and second with Delphi method that DMs selected 3 factors in 23 critaria of Dikson.

My DMs are president of company, purchasing manager, quality control manager and purchasing agent, In this auto Asembling company we have three suppliers for auto Bumper. The conceptual model of paper is shown in figure 1.

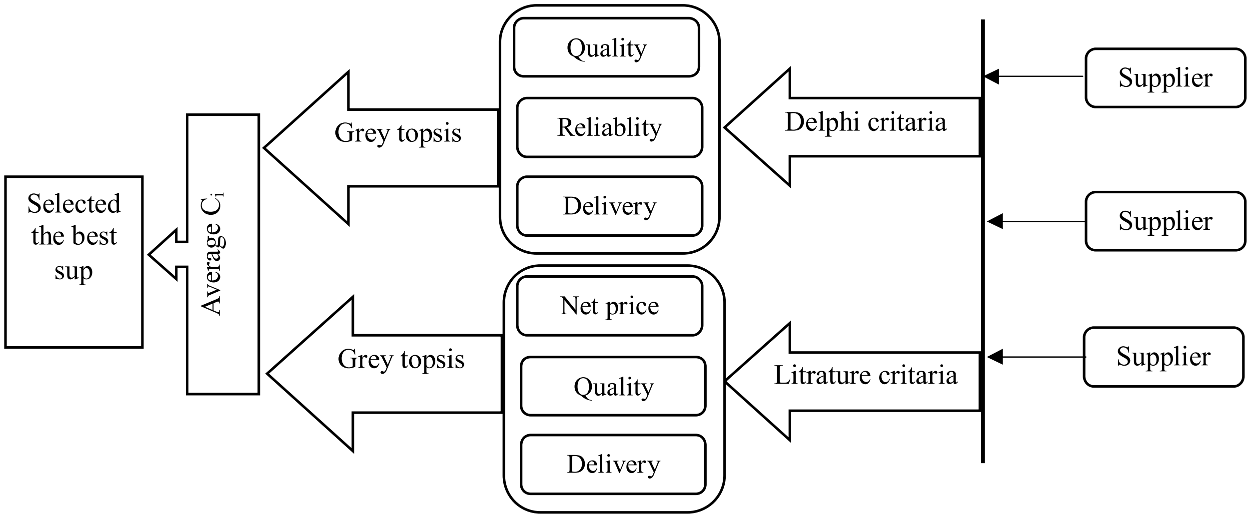

Figure 1: The structure of supplier selection process selection ssselection

3. Topsis and grey Topsis:

TOPSIS, developed by Hwang and Yoon in 1981, is a simple ranking method in conception and application. The standard TOPSIS method attempts to choose alternatives that simultaneously have the shortest distance from the positive ideal solution and the farthest distance from the negative-ideal solution. The positive ideal solution maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria. TOPSIS makes full use of attribute information, provides a cardinal ranking of alternatives, and does not require attribute preferences to be independent (Behzadian et al, 2012).

Lin et al. (2008) proposed the model of TOPSIS method with attributes values determined at intervals (TOPSIS grey) that includes the following steps:

Step 1: Selecting the set of the most important attributes, describing the alternatives.

Step 2: Constructing the decision-making matrix ⊗X. Grey number matrix ⊗X can be defined as:

$$\otimes X = \begin{bmatrix} \otimes x_{11} & \cdots & \otimes x_{1m} \\ \vdots & \ddots & \vdots \\ \otimes x_{n1} & \cdots & \otimes x_{nm} \end{bmatrix} \qquad (1)$$

where $\otimes x_{ij}$ denotes the grey evaluations of the i-th alternative with respect to the j-th attribute; (⊗i1 x ⊗i2 x ,..., ⊗x im) is the grey number evaluation series of the i-th alternative, i =1,n , j =1,m .

Step 3: Constructing the normalized grey decision matrices. The normalized values of maximizing attributes are calculated as (Lin et al., 2008):

$$\otimes \bar{x}_{ij,b} = \frac{\otimes x_{ij}}{max_i(b_{ij})} = \left(\frac{w_{ij}}{max_i(b_{ij})}, \frac{b_{ij}}{max_i(b_{ij})}\right) \qquad (2)$$

where w_{ij} and b_{ij} are lower and upper values of attributes, respectively (Zavadskas et al., 2010a).

The normalized values of minimizing attributes are calculated as:

$$\otimes \bar{x}_{ij,w} = 1 - \frac{\otimes x_{ij}}{max_i(b_{ij})} = \left(1 - \frac{b_{ij}}{max_i(b_{ij})}, 1 - \frac{w_{ij}}{max_i(b_{ij})}\right) \qquad (3)$$

Step 4: Determining weights of the criteria q_j(Zolfani, 2012).

Step 5: Constructing the grey weighted normalized decision-making matrix.

$$D^* = \begin{bmatrix} \otimes v_{11} & \otimes v_{12} & \otimes v_{13} \\ \otimes v_{21} & \otimes v_{22} & \otimes v_{23} \\ \otimes v_{31} & \otimes v_{32} & \otimes v_{33} \end{bmatrix} \qquad (4)$$

That:

$$\otimes v_{ij} - \otimes \bar{x}_{ij,b} * \otimes w_j \qquad (5)$$

(Li et al, 2007)

Step 6: Determining the positive and negative ideal alternatives for each decision-maker. The positive ideal alternative A^+, and the negative ideal alternative A^- can be defined as:

$$A^+ = \{(max_i b_{ij} | j = J), (min_i w_{ij} | j = J')\} / [i \in n] = [x_1^+, x_2^+, ..., x_m^+], \qquad (6)$$

$$A^- = \{(min_i w_{ij} | j = J), (max_i b_{ij} | j = J')\} / [i \in n] = [x_1^-, x_2^-, ..., x_m^-], \qquad (7)$$

Step 7: Calculating the separation measure from the positive and negative ideal alternatives, d_i^+ and d_i^-, for the group. There are two sub-steps to be considered: the first one concerns the separation measure for individuals; the second one aggregates their measures for the group. Accordingly, the measures from the positive and negative ideal alternatives should be calculated individually. For decision-maker k, the separation measures from the positive ideal alternative and negative ideal alternative are computed through weighted grey number:

$$d_i^+ = \left\{\frac{1}{2}\sum_{j=1}^{m} q_j\left[|x_j^+ \quad \bar{w}_{ij}|^p + |x_j^+ \quad \bar{b}_{ij}|^p\right]\right\}^{1/p} \tag{8}$$

$$d_i^- = \left\{\frac{1}{2}\sum_{j=1}^{m} q_j\left[|x_j^- - \bar{w}_{ij}|^p + |x_j^- - \bar{b}_{ij}|^p\right]\right\}^{1/p} \tag{9}$$

for $p \geqslant 1$ and integer, q_j is the weight for the attribute j, which determined with Delphi methods.

Step 8: Calculating the relative closeness c_i^+ to the positive ideal alternative for the group. The aggregation of relative closeness for the i-th alternative with respect to the positive ideal alternative for the group can be expressed as:

$$c_i^+ = \frac{d_i^-}{d_i^+ + d_i^-} \tag{10}$$

where $0 \leqslant ci+ \leqslant 1$

The larger the index value is the better the evaluation of alternative will be.

Step 9: Rank the preference order. A set of alternatives now can be ranked by the descending order of the value of c_i^+(Zolfani et al, 2012).

4. Case study:

In this section a real case in an auto company for the product of bumper will be solved and the best supplier will be selected.

4-1) ranked with Delphi critaria and grey topsis

First of all DMs deside to have three critaria to evaluate suppliers. So we use Delphi method to select three critaria from 23 critaria factors of Dikson. This three factor are quality, delivery and reliablity. So DMs evaluate three suppliers with three factors. As we see below:

DMs use verbal signals for atribute rating and attribute weights as shown in table 2&3.

Table 2:The scale of attribute weights ⊗w

Very low(VL)	(0.0,0.1)
Low(L)	(0.1,0.3)
Medium low(ML)	(0.3,0.4)
Medium(M)	(0.4,0.5)
Medium high(MH)	(0.5,0.6)
High(H)	(0.6,0.9)
Very high(VH)	(0.9,1.0)

Table 3:The scale of attribute ratings ⊗G

Very poor(VP)	(0,1)
Poor(P)	(1,3)
Medium poor(MP)	(3,4)
Fair(F)	(4,5)
Medium good(MG)	(5,6)
Good(G)	(6,9)
Very Good(VG)	(9,10)

The values of three attributes weights by four DMs are shown in below table:

Critaria	DMs	⊗W
Quality	F	(0.4,0.5)
Reliablity	VG	(0.9,0.1)
Delivery	MP	(0.3,0.4)

Four DMs, D1, D2, D3 and D4, are going to evaluate three suppliers as alternatives against product quality Q1, reliability(performance history) Q2, delivery time Q3. Where Q1, Q2 and Q3 are benefit attributes.(200)

$$\otimes X = \begin{bmatrix} [6,9] & [9,10] & [4,5] \\ [4,5] & [6,9] & [9,10] \\ [6,9] & [6,9] & [4,5] \end{bmatrix}$$

$$\otimes \bar{x}_{ij,b} = \begin{bmatrix} [0.66,1] & [0.9,1] & [0.4,0.5] \\ [0.44,0.55] & [0.6,0.9] & [0.9,1] \\ [0.66,1] & [0.6,0.9] & [0.4,0.5] \end{bmatrix}$$

$$\otimes w_j - [[0.4,0.5] \quad [0.9,1] \quad [0.3,0.4]]$$

$$D^* = \begin{bmatrix} [0.66,1] & [0.9,1] & [0.4,0.5] \\ [0.44,0.55] & [0.6,0.9] & [0.9,1] \\ [0.66,1] & [0.6,0.9] & [0.4,0.5] \end{bmatrix} \times \otimes w_j$$

$$- \begin{bmatrix} [0.26,0.5] & [0.81,1] & [0.12,0.2] \\ [0.18,0.27] & [0.54,0.9] & [0.27,0.4] \\ [0.26,0.5] & [0.54,0.9] & [0.12,0.2] \end{bmatrix}$$

$$A^{+} = \{[0.26,0.5] \quad [0.81,1] \quad [0.27,0.4]\}$$

$$A \;\; = \{[0.18,0.27] \quad [0.54,0.9] \quad [0.12,0.2]\}$$

suppliers	di+	di-	ci+	Rank
s1	0.468	1.025	0.687	1
s2	1.025	0.468	0.313	3
s3	1.003	0.513	0.338	2

4-2) ranked with litrature critaria and grey topsis:

By Weber three critaria that exterimly used with researchers are net price, delivery and quality that these three criteria were rated as having extreme or considerable importance by Dickson. We used these three critaria for second ranking method in supplie selection process.

The values of three attributes weights by four DMs are calculated is shown in below table:

critaria	DMs	⊗W
Net price	MP	(0.3,0.4)
Quality	F	(0.4,0.5)
Delivery	G	(0.6,0.9)

Four DMs, D1, D2, D3 and D4, are going to evaluate three suppliers as alternatives against product net price Q1, quality Q2, delivery time Q3. Where Q1 iscost attribute and Q2 and Q3 are benefit attributes.(200)

$$\otimes X = \begin{bmatrix} [1,3] & [6,9] & [4,5] \\ [5,6] & [4,5] & [9,10] \\ [5,6] & [6,9] & [4,5] \end{bmatrix}$$

$$\otimes \bar{x}_{ij,b} = \begin{bmatrix} [0.5,0.83] & [0.66,1] & [0.4,0.5] \\ [0,0.17] & [0.44,0.55] & [0.9,1] \\ [0,0.17] & [0.66,1] & [0.4,0.5] \end{bmatrix}$$

$$\otimes w_j = [[0.3,0.4] \quad [0.4,0.5] \quad [0.6,0.9]]$$

$$D^* = \begin{bmatrix} [0.5,0.83] & [0.66,1] & [0.4,0.5] \\ [0,0.17] & [0.44,0.55] & [0.9,1] \\ [0,0.17] & [0.66,1] & [0.4,0.5] \end{bmatrix} \times \otimes w_j$$

$$= \begin{bmatrix} [0.15,0.33] & [0.26,0.5] & [0.24,0.45] \\ [0,0.07] & [0.18,0.45] & [0.54,0.9] \\ [0,0.07] & [0.26,0.5] & [0.24,0.45] \end{bmatrix}$$

$$A^{+} = \{[0,0.07] \quad [0.26,0.5] \quad [0.54,0.9]\}$$

$$A^{-} = \{[0.15,0.33] \quad [0.18,0.45] \quad [0.24,0.45]\}$$

suppliers	di+	di-	ci+	Rank
s1	1.586	0.215	0.119	3
s2	0.215	1.586	0.881	1
s3	1.481	0.607	0.291	2

Now we calculate average c_i of suppliers by two methods:

Suppliers	Average c_i^+	Final rank
S1	0.403	2
S2	0.597	1
S3	0.314	3

As a result, by combining of the two methods, supplier2 is selected as the best supplier.

5. Conclusion:

Supplier selection and evaluation are very important to the success of a manufacturing firm. purchasing and supplier selection play an important role in supply chain management. Therefore, the selection of appropriate suppliers is a very important problem for any organization. So Grey Topsis and Delphi method can help companies to select the best suppliers in multi criteria. Results show that litrature selected critaria are different from Delphi selected critaria in some case. So we can compound two method with avrage c_i^+ of suppliers. Base on calculation supplier 2 is the best one and after it supplier 1 is in second rank.

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