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Using Data Envelopment Analysis for Green Supplier Selection in Manufacturing under Vague Environment

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Abstract. In these days, considering the growth of knowledge about environmental protection and green issues in manufacturing, green supplier selection would be the central component in the management of supply chain. This paper intends to apply data envelopment analysis for supplier selection considering environmental merits. The suppliers' performances with respect to criteria are not pure numbers and considered in linguistic terms according to decision makers' opinion. To handle the subjectivity of decision makers' assessments, fuzzy logic has been applied. A case study is done to present the application of the method.

Introduction

In recent years, due to the growth of knowledge about environmental protection, green supply chain management (GSCM) should receive due academic and practical attentions. The GSCM should be able to reduce environmental pollution from upstream to downstream when purchasing raw materials, manufacturing, distribution, selling products and obsolescing products [1]. Suppliers are the key partners of supply chains and selection of the suppliers must be done carefully, because they can have a very positive or adverse impact on the overall performance of an organization. In supplier selection decision process, two fundamental questions must be addressed. Firstly, what criterion should be used, and secondly, what methods can be applied to compare the potential suppliers [2]. Since, several criteria to be considered in supplier selection process, DEA approach based on multiple inputs and outputs is one of the appropriate tools [3-7]. On the other hand, by considering decision makers' preferences in the supplier selection process, the vagueness and ambiguity appears. To deal with this uncertainty and to handle humane assessments, fuzzy set theory is an efficient tool [8].

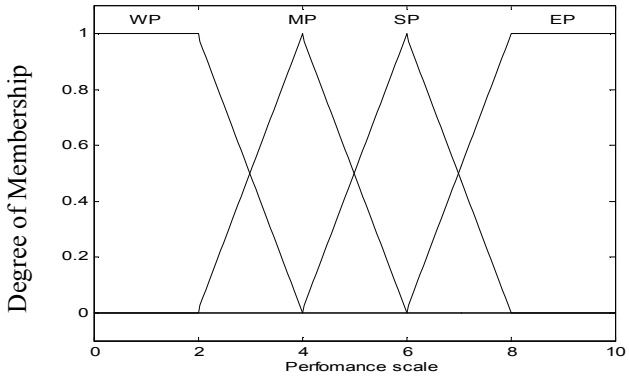

Fig. 1. Membership functions for supplier's rating

Fuzzy Set Theory

Zadeh (1965) introduced fuzzy set theory to cope with the imprecision and uncertainty which is inherent to the human judgments in decision making processes through the use of linguistic terms and degrees of membership [9]. In this work the supplier's performance with respect to criteria are in

linguistic terms on the basis of decision makers' opinion. Thus, we set out trapezoidal membership functions for estimation of the supplier's performance as shown in Fig. 1 .

Data Envelopment Analysis

Data Envelopment Analysis (DEA) proposed by Charnes, Cooper, and Rhodes (CCR) (1978) is a mathematical programming method for assessing the relative efficiency of homogenous decision making units (DMU) with multiple inputs and outputs. DEA is a non-parametric method that lets efficiency be measured without having specific weights for inputs and outputs or specify the form of the production function.

In supplier selection, the performance of a supplier is calculated using the ratio of weighted outputs to weighted inputs [10]. The goal of the firm is to choose one or more suppliers from n candidates. In order to calculate the set of efficiencies for *n* suppliers, *n* fractional programming models are solved. The problem can be changed into linear programming. The model for supplier *k* could be defined as follows Eq. (1).

$$\begin{aligned} & MaxZ_k = \sum_{r=1}^{s} u_r y_{rk} \\ & st: \\ & \sum_{i=1}^{m} v_i x_{ik} = 1 \\ & \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \qquad (j = 1,2,...,n) \\ & u_r, v_i \ge \varepsilon \end{aligned} \tag{1}$$

Where: *k* is the under evaluation unit; *s* represents the number of outputs; *m* represents the number of inputs; y_{rj} is the amount of output *r* provided by unit *j*; *xij* is the amount of input *i* used by unit; u_r and v_i are the weights given to output and input respectively.

Green Supplier Selection

The case study presented in this paper stands for one of the pocket and box manufacturer in Iran(X Company). To identify the supplier selection criteria, we arranged some meetings and carried out interviews with managers and staffs and discussed about the appropriate criteria. After verifying a group of criteria in a view point of environmental merits, some criteria including environmental costs, reuse-recycle, environmental management system, green R&D, and air pollution are derived.

Exertion and Discussion

The information about the candidate suppliers in the mentioned company is shown in *Table 1*. The results of this Table are diffuzified with center of area (COA) method and then normalized [8] as shown in *Table 2* . By applying DEA Excel Solver software and implementing DEA model considering *Table 2* as inputs and outputs data, the efficient and inefficient suppliers are identified as shown in *Table 3*. To implement DEA model, the input and output dimensions must be defined firstly. Normally, the criteria which the smaller is better consider as inputs and the criteria which the larger is better consider as outputs to increase the efficiency. So in this research environmental costs and air pollution are considered as inputs and environmental management system, reuse-recycle, and green R&D are considered as outputs. Suppliers S1,S2, and S6 are are inefficient because their efficiency is less than one but the others which obtained the efficiency equal to one are efficient. In *Table 3*, the optimal weights for inputs and outputs are shown. But, it is better to shift these weights because in some cases the weights are considered equal to zero. So, the target value for inputs and outputs are calculated as shown in *Table 4*.

Table 1:Suppliers' fuzzy data in X Company

suppliers	Inputs		Output		
	EC	AP	RE	EMS	G-R&D
S1	EP(6,8,10,10)	MP(2,4,4,6)	SP(4,6,6,8)	MP(2,4,4,6)	MP(2,4,4,6)
S2	SP(4,6,6,8)	MP(2,4,4,6)	WP(0,0,2,4)	MP(2,4,4,6)	WP(0,0,2,4)
S3	MP(2,4,4,6)	WP(0,0,2,4)	WP(0,0,2,4)	WP(0,0,2,4)	EP(6,8,10,10)
S4	SP(4,6,6,8)	MP(2,4,4,6)	EP(6,8,10,10)	SP(4,6,6,8)	MP(2,4,4,6)
S5	WP(0,0,2,4)	EP(6,8,10,10)	WP(0,0,2,4)	EP(6,8,10,10)	MP(2,4,4,6)
S6	EP(6,8,10,10)	SP(4,6,6,8)	SP(4,6,6,8)	WP(0,0,2,4)	SP(4,6,6,8)

Table 2: The input and output data of the DEA model

suppliers	Inputs		Output		
	EC	AP	RE	EMS	G-R&D
S1	0.8444	0.4	0.6	0.4	0.4
S2	0.6	0.4	0.2083	0.4	0.2083
S3	0.4	0.2083	0.2083	0.2083	0.8444
S4	0.6	0.4	0.8444	0.6	0.4
S5	0.2083	0.8444	0.2083	0.8444	0.4
S6	0.8444	0.6	0.6	0.2083	0.6

Table 3: Efficiency values and optimal multipliers of suppliers

		Input-Oriented CRS	Optimal Multipliers				
DMU No.	DMU Name	Efficiency	EC	AP	RE	EMS	G-R&D
1	Supplier1	0.75311	0.00000	2.50000	1.01018	0.00000	0.36752
2	Supplier 2	0.66667	0.66490	1.50265	0.00000	1.66667	0.00000
3	Supplier 3	1.00000	2.50000	0.00000	0.00000	0.00000	1.18427
4	Supplier 4	1.00000	1.66667	0.00000	1.18427	0.00000	0.00000
5	Supplier 5	1.00000	0.47246	1.06773	0.00000	1.18427	0.00000
6	Supplier 6	0.62803	1.13646	0.06729	0.65280	0.00000	0.39391

Conclusion

Today, environmental protection has been received a lot of attentions and consequently green supplier selection is a vital issue of supply chain management in manufacturing. On the other hand, supplier selection is a multi-criteria decision making which can be involved high degree of vagueness according to decision makers' opinion. So, fuzzy logic has been applied to handle the vagueness and DEA model has been implemented as a multi-criteria decision making method to determine the efficient and inefficient suppliers.

Table 4: Target values for inputs and outputs

DMU No.	DMU Name	Efficient Input Target EC	AP	Efficient Output Target RE	EMS	G-R&D
1	Supplier 1	0.46546	0.30125	0.60000	0.43570	0.40000
2	Supplier 2	0.40000	0.26667	0.56293	0.40000	0.26667
3	Supplier 3	0.40000	0.20830	0.20830	0.20830	0.84440
4	Supplier 4	0.60000	0.40000	0.84440	0.60000	0.40000
5	Supplier 5	0.20830	0.84440	0.20830	0.84440	0.40000
6	Supplier 6	0.53031	0.37682	0.60000	0.49610	0.60000

References

[1] R. Kuo, *et al.*, "Integration of Artificial Neural Network and MADA Methods for Green Supplier Selection," *Journal of Cleaner Production,* 2010.

[2] A. Amindoust, Ahmed, S., Saghafinia, A., "Supplier Selection and Performance Evaluation of Telecommunication Company," *American J. of Engineering and Applied Sciences,* vol. 5, pp. 49-52, 2012.

[3] S. Talluri and R. C. Baker, "A multi-phase mathematical programming approach for effective supply chain design," *European Journal of Operational Research,* vol. 141, pp. 544-558, 2002.

[4] S. Talluri and R. Narasimhan, "A methodology for strategic sourcing," *European Journal of Operational Research,* vol. 154, pp. 236-250, 2004.

[5] R. F. Saen, "Using super-efficiency analysis for ranking suppliers in the presence of volume discount offers," *International Journal of Physical Distribution & Logistics Management,* vol. 38, pp. 637 - 651, 2008.

[6] R. M. Garfamy, "A data envelopment analysis approach based on total cost of ownership for supplier selection," *Journal of Enterprise Information Management,* vol. 19, pp. 662 - 678, 2006.

[7] J. Liu, *et al.*, "Using data envelopment analysis to compare suppliers for supplier selection and performance improvement," *Supply Chain Management: An International Journal,* vol. 5, pp. 143-150, 2000.

[8] A. Amindoust, Ahmed, S., Saghafinia, A., Bahreininejad, A., "Sustainable supplier selection: A ranking model based on fuzzy inference system," *Applied Soft Computing,* vol. 12, pp. 1668-1677, 2012.

[9] L. A. Zadeh, "Fuzzy sets*," *Information and control,* vol. 8, pp. 338-353, 1965.

[10] A. Amindoust, Ahmed, S., Ketabi, S., "Evaluation and Selection of Supplier in Supply Chain Network Based on DEA," *The 11th Asia Pacific Industrial Engineering and Management Systems Conference,* 2010.

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