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Supplier Selection and Performance Evaluation of Telecommunication Company

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Abstract: Problem statement: In today's manufacturing outsourcing of resources has significant importance. Efficient supplier selection process is a central part in supply chain management for enterprises for outsourcing. **Approach:** The nature of supplier selection is a multi criteria decision making problem and in the selection process multiple criteria must be considered. In this study a multiple attribute utility theory base on Data Envelopments Analysis (DEA) applied to tackle this problem with consideration of some inputs and outputs. **Results:** A real case study was implemented to show the application of DEA method and through this method the efficient and inefficent suppliers were identified to ranking them. **Conclusion:** DEA is a tactical model to cope with multiple criteria in purchasing decisions.

Key words: Supplier selection, supply chain management, DEA

INTRODUCTION

Supply Chain Management (SCM) has been an important subset for almost 25 years and consists of activities like procuring materials, transforming them in to final products and delivering the products to customers (Cebi and Bayraktar, 2003). Suppliers are the key part of the supply chain. So selecting the suppliers must be done carefully, because they can have a very positive or adverse impact on the overall performance of the organization. In supplier selection decisions, two fundamental questions must be addressed. Firstly, what criterion should be used and secondly, what methods can be used to compare suppliers.

Literature in supplier selection is available since 1960's, when (Dickson, 1966) identified the importance of 23 supplier selection criteria for industrial purchasing, which deeply influenced later researches in this area. The basic attributes in Dickson's criteria were quality, delivery, performance history, warrantee and claim policies, production facilities and capacity and price (Dickson, 1966). Weber *et al*. (1991) work provided an explicit overview on issues of supplier selection up to 1991. His basic attributes were price, delivery, quality, production facilities and capacity, geographical location and technical capability (Weber *et al*., 1991). After that, (Zhang *et al*., 2003) summarized the literature on supplier selection issues from 49 articles published during 1992-2003. In their study the most important criteria were price, quality, delivery, production facilities and capacity, technical capability and financial position (Zhang *et al*., 2003). At last (Ho *et al*., 2010) worked on some articles about supplier selection from 2000-2008 and discovered the most popular criterion considered by the decision makers is quality, followed by delivery, price/cost, manufacturing capability, service and management (Ho *et al*., 2010).

Several techniques for supplier selection have been proposed in the literature. The first group is Mathematical programming models are used. For example data envelopment analysis (Azadeh *et al*., 2008), a fuzzy mixed integer goal programming (Sawik, 2010) and a mixed integer non-linear programming (Kheljani *et al*., 2009). The second is linear weighting models used in Analytic hierarchy process (Lee, 2009) and interpretive structural modeling (Yang *et al*., 2008).

There are also some other methods employed in supplier selection such as Total Cost of Ownership (TCO) (Degraeve *et al*., 2000), Activity Based Cost (ABC), fuzzy logic approach (Yucel and Guneri, 2010).

In this research Ho' criteria are considered, for evaluating and comparing the suppliers. These criteria are classified in to input and output factors. Inputs are the factors that are consider influencing in producing the chosen output factors. Because of multiple inputs

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and multiple outputs, DEA is an appropriate tool for evaluation and selection of suppliers.

This article is organized as follows: First the proposed methodology is shown for solving the supplier selection problem. Then, the most important factors for supplier selection are detemined and the inputs and outputs are identified and calculated. Finally, results and data analysis are presented.

MATERIALS AND METHODS

Data Envelopment Analysis (DEA) proposed by Charnes, Cooper and Rhodes (CCR) 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 (Chen *et al*., 2007).

In supplier selection, the performance of a supplier is calculated using the ratio of weighted outputs to weighted inputs. 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:

$$\text{Max}Z_k = \sum_{r=1}^{s} u_r y_{rk} \quad (1)$$

$$\text{st}: \sum_{i=1}^{m} v_i x_{ik} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} £ 0 \left(j = 1, 2, .., n\right) u_r, v_i ³ \varepsilon$$

Where:

K = Is the unit begins evaluated
S = Represents the number of outputs; m represents the number of inputs
y_{ri} = Is the amount of output r provided by unit j; ij_x is the amount of input
I = used by unit
j: u_i and v_r = Are the weights given to output r and input
I = Respectively

Identification of criteria in our case study: The case study presented in this study stands for one of the divisions of Telecommunications Company in Iran, which supplies digital systems for this company and it is referred to as company X throughout the article. The company's goals in supply chain management included improving the quality of purchased cables, lead-time reduction and long-term relationships with reliable suppliers and securing global competitive pricing. To identify the supplier selection criteria based on achieving these goals, we arranged some meetings and carried out interviews with managers and staffs and discussed about the appropriate criteria. After verifying a group of criteria, it appeared that Ho's criteria were the best and closest criteria for achieving the goals. So in this study Ho's criteria were considered that included quality, delivery and price/cost, manufacturing capability, service and management.

Firstly the input and output dimensions must be defined for implementing in DEA method. Typically, the resources used by purchasing managers and referred to supplier capability should be included as inputs and supplier performance criteria as outputs (Saen, 2008). So in this research price, quality, delivery and service were considered as outputs and manufacturing capability and management were considered as inputs.

Secondly the important issue is that how to calculate these inputs and outputs. For quality indicator the amount of rejected items was considered. For calculating this indicator (Saen, 2010), the amount of rejected items divide the worth of total items. For measuring delivery index, the average of amount of items that have delayed deliveries over the last n supplies has been considered. Briefly for price, it was considered the price of the item to be purchased, that is the average price of purchased unit. For manufacturing capability, the percentage of the technical staff was considered. For service, the numbers of customers' claims were calculated and reversed. Finally for management criterion we calculated the averaged between the managers' experience and the level of their education.

RESULTS

The data of eleven suppliers of company X were considered for the analysis. The inputs and outputs were calculated as mentioned before. The CCR model of DEA was conducted for eleven suppliers with DEA EXCEL SOLVER software and the results are shown in the following tables. Table 1 shows the supplier's attributes. These measures are the normalized values of the four output factors and the two input factors. Table 2 shows the efficiency scores of suppliers.

Suppliers 1, 2, 4, 6, 8, 9 and 10 are inefficient with scores of less than 1. The remaining 4 suppliers are efficient with scores of 1. This table also shows the optimal weights of input and output factors for each supplier.

Table 1: Suppliers performance

	Outputs				
Manufacturing capability	Management	Quality	Delivery	Price	Service
0.458963	0.772727	0.699999	0.963119	0.989299	0.500000
0.547757	0.809524	0.744680	0.959188	0.996442	0.250000
0.41844	0.607143	1.000000	1.000000	0.989299	1.000000
0.698742	0.548387	0.751072	0.876216	1.000000	0.100000
0.443104	0.485714	0.726141	0.940004	0.987529	0.200000
1	0.772727	0.833333	0.946821	0.998244	0.200000
0.951997	0.414634	0.925925	0.886796	0.989299	0.100000
0.943755	1.000000	0.879396	0.936259	0.996442	0.500000
0.48554	0.607143	0.833333	0.815410	0.989299	0.100000
0.425796	0.680000	0.751072	0.854549	0.998244	0.142857
0.41844	0.705394	0.726141	0.845328	0.991431	0.200000

Table 2: Efficiency and optimal weights for criteria

	Optimal multiplier					
Efficiency	Manufacturing capability	Management	Quality	Delivery	Price	Service
0.91125	2.17882	0.00000	0.00000	0.01253	0.90891	0.00000
0.76924	1.80087	0.01675	0.00000	0.00000	0.77199	0.00000
1.00000	0.00000	1.64706	0.70579	0.00000	0.00000	0.29421
0.85796	0.21875	1.54480	0.00000	0.00000	0.85796	0.00000
1.00000	0.40000	1.69391	0.58018	0.61564	0.00000	0.00000
0.62401	0.23406	0.99121	0.33950	0.36025	0.00000	0.00000
1.00000	0.00000	2.41177	1.08000	0.00000	0.00000	0.00000
0.53368	0.23582	0.77744	0.32185	0.00000	0.25153	0.00000
0.89067	1.62933	0.34406	0.00000	0.00000	0.90031	0.00000
0.99028	2.31416	0.02153	0.00000	0.00000	0.99202	0.00000
1.00000	2.35293	0.02189	0.00000	0.00000	1.00864	0.00000

Table 3: Benchmark value

Shadow price	Reference set	Shadow price	Reference set	Shadow price	Reference set
0.764	3.0000	0.235	11.000		
0.892	3.0000	0.115	11.000		
1.000	3.0000				
0.715	5.0000	0.297	7.0000		
1.000	5.0000				
0.087	3.0000	0.593	5.0000	0.341	7.000
1.000	7.0000				
0.441	3.0000	0.433	5.0000	0.133	7.000
0.449	3.0000	0.552	5.0000		
0.381	3.0000	0.627	11.000		
1.000	11.000				

DISCUSSTION

For every inefficient unit, DEA identifies a set of efficient units that can be utilized as benchmarks for improvement of inefficient units. In fact, shadow prices that are not equal to zero, make dummy units with composition of reference sets for evaluation. Table 3 shows these results. For example for evaluating the efficiency of supplier 1 which is inefficient, dummy unit is made with suppliers 3, 11 (references) with multipliers 0.764, 0.235 (shadow prices).

CONCLUSION

In supply chain management, the essence of supplier selection problem is how to made long period collaboration among different parts in supply chain network. Supplier selection is a multi-criteria decision making which faces multiple inputs and outputs. To deal with multiple inputs and outputs this study applies DEA as a tactical model in purchasing decisions. Also this study shows the real results and presents the application of the method through a case study for a manufacturing firm. In this study, in spite of presenting the efficient and inefficient suppliers, some useful evaluation points about suppliers' performance are highlighted.

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