Screening Efficiency and Entrepreneurship Potential in Automotive Suppliers Using DEA

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Abstract

This study aims to screen entrepreneurial potentials of automotive manufacturing and performance criteria. Supplier selection as a key part of supply chain management (SCM) facilitates the creation of sustainable competitive advantage that can cause new ventures and business growth development. Efficient supplier selection method is a main part in SCM for outsourcing in businesses. The character of supplier selection is a multi-criteria decision making (MCDM) problem and multiple criteria should be respected in the selection procedure. This study assessed the suppliers' efficiency through Data Envelopments Analysis (DEA).

Introduction

In the late 1980s, the expression "supply chain management" (SCM) was coined and it became popular in the 1990s. Earlier, terms such as "operations management" and "logistics" were used in place of SCM [1]. According to Hogus [1], SCM is the harmonization of "production, inventory, location, and transportation" amid the members in a supply chain to accomplish the best combination of "responsiveness" and "efficiency". SCM comprises actions like procuring materials, transforming them in to end products and delivering to customers [2]. Suppliers are the main component of supply chain, hence, selecting the suppliers mainly concern of managers since they influence overall efficiency of supply chain [3]. Two main points should be considered in supplier selection processes are the type of criterion used and the method applied to compare them.

Materials and Methods

Twenty three important supplier selection criteria were presented by Dickson in 1996 [4]. This is known widely as a start point for conducting most of literature researches on the supplier selection. The basic aspects in Dickson's criteria were: quality, delivery, performance history, warrantee and claim policies, production facilities and capacity and price. To identify and prioritize effective criteria to choose suppliers, review of literatures in this field shows that the most important criteria (six criteria) applied in earlier studies can be extracted as follows: quality, delivery time, price, ability to produce, after-sale services and management approach [5]. Later, Weber [6] pointed that the issue of selecting a supplier is inherently a multi-target issue and considering more than one criterion can lead to a successful evaluation and selection of suppliers. In other words, traditional criteria should be replaced by new and comprehensive criteria to create strategic relation between members of supply chain. Further, due to the fear of competition in major industries, many companies adopt strategies which link to added value creation and entrepreneurial attribute since the entrepreneurship is a factor influencing in producing the selected output factors and performance [7].

Literature in techniques of supplier selection showed that the studies benefited from two main methods. First group of scholars applied individually approaches like DEA [8], mathematical programing methods (such as: linear programing [9], integer linear programming [10], integer non-linear programming [11], goal programming [12], multi objective programming [13], AHP [14], case-based reasoning [15], ANP [16], fuzzy [17], simple multi-attribute rating [18], and GA [19]. The second group utilize integrated approaches like integrated AHP approaches [20], integrated fuzzy approaches [21], and other integrated approaches [22, 23]. This study considered the entrepreneurial orientations of the suppliers as inputs and five criteria of Ho et al. [5], as outputs for evaluating and ranking suppliers. Due to multiple inputs and outputs, DEA method is applicable for measuring and selecting the efficient suppliers.

This paper is shaped as follows: first, the suggested methodology is presented for solving the supplier selection issue. Then, the most significant factors for selection of supplier are determined and the inputs and outputs are distinguished and evaluated. Ultimately, findings from data analysis are reported.

Efficiency Measurement Methods

Generally, there are two methods to measure efficiency: parametric and nonparametric. DEA is one of the nonparametric approaches. To calculate efficiency by using DEA, weighted average of outputs over inputs is used. Any possible weight can be given to maximize efficiency frontier of a unit provided that if the weight used in a unit is also considered in calculating efficiency of another unit, the efficiency will be less or equal to 1 (≤ 1) [24].

In supplier selection, the efficiency of a supplier is evaluated by employing the ratio of weighted outputs to weighted inputs. The aim of the company is to select efficient suppliers among candidates.

After changing the problem to linear programming, the model could be as follow:

$$\textbf{Max Z} = \theta - \boldsymbol{\varepsilon}\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

Subject to:

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

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \theta y_{r0}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0, s_{r0}^+ \geq 0, s_{i0}^- \geq 0$$

Where:

1: $s_i^-, s_r^+ = \textit{slacks}$
2: λ is a nonnegative vector in $\boldsymbol{R^n}$.
3: (i=1, 2… m), (j=1, 2… n), (r=1, 2… s), θ free in sign
$\textbf{y}_r = \textbf{amount of output for r}, \textbf{x}_i = \textbf{amount of input i}$

Equation 1: Output-oriented and BCC Model

Identification of criteria of the study:

The target population of this case study was the 12 main plastic parts supplier for Iran Khodro, the well-known biggest Iranian automotive company. This study monitored the main concerned criteria by managers and owners through study of the used secondary data (applied criteria in plastic parts suppliers). This part of the study revealed that the criteria which were employed for measuring efficiency in almost all Iranian automotive industries were close to Garvin's [25] indicators, quality, service, flexibility, cost/price and delivery. In addition, this study draws attention to some entrepreneurial criteria, as this study aimed to measure efficiency of each supplier in the viewpoint

of entrepreneurial potential. According to Stevenson [26], the six dimensions of entrepreneurship are: strategic orientation, resource orientation, management structure, growth orientation, entrepreneurial culture, and reward philosophy. The high score in each dimension indicates the high level of attention to entrepreneurial behaviour by managements. Stevenson categorized the management behaviour of the promoter and trustee types along six mentioned dimensions. The inputs and outputs dimensions should be specified in order to apply DEA method. As a rule, the resources employed by managers and referred to capability of supplier must be included as inputs while, supplier performance criteria were considered as outputs [27].

As a whole, this study applied six dimensions of Stevenson's entrepreneurship (which were strategic orientation, resource orientation, management structure, growth orientation, entrepreneurial culture, and reward philosophy) and five performance indicators of Garvin (including: quality, service, flexibility, cost/price and delivery). The following conceptual framework (Figure 1) was developed for each suppliers (or DMUs):
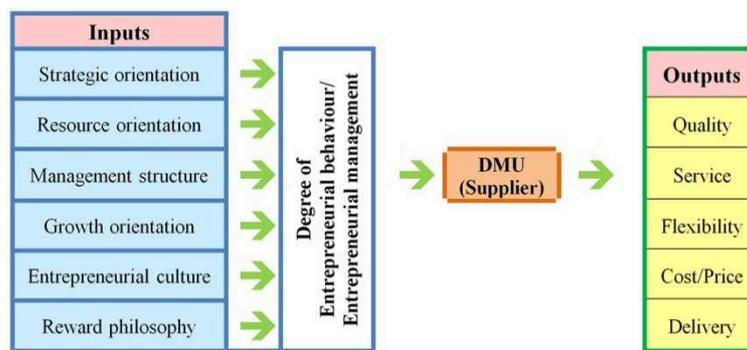

Figure 1: Conceptual Framework of the Study

This model proposed that the inputs are calculated according to Stevenson's viewpoint. In fact, inputs indicated the degree of entrepreneurial management [26]. Further, the outputs of this study are indicating the level of suppliers' performance [25]. The degree of entrepreneurial management was calculated through the 21-item-questionnaire of Brown et al. [28], from 12 plastic suppliers' employees. The returned questionnaire from respondents were 108. These 12 scores are indicating inputs of each supplier. The score of outputs′ dimensions are calculated through the sum of the related items which were obtained through the secondary data. For example, in order to measure of delivery dimension, the average of amount of products that have delayed deliveries over the last m supplies has been considered. The amount of rejected products was considered for quality dimension. The amounts of rejected products divided by the value of total products was taken to calculate this indicator [3]. The data of 12 suppliers of Iran Khodro Company were analysed. The inputs and outputs were determined as aforesaid. The output-oriented model of DEA of DEAP software was employed to determine the efficiency of the 12 suppliers. The illustrated results in Table 1 indicates that Suppliers 2, 3, 6, 7, 8, 10 and 12 are inefficient because their scores are less than 1. The remaining 5 suppliers are considered efficient since their efficiency scores are equal to 1. In addition, this table indicates which inputs should be adopted by each inefficient supplier in order to become efficient. For every inefficient supplier, DEA recognizes a set of efficient units (or peers) that can be employed as benchmarks for improving inefficient suppliers. According to obtained results in Table 1, supplier 1 was found to be both technical and scale efficient and operating in the most productive scale size when compared to 11 other peers DMUs. In addition, supplier 1 was a peer to many other supplier firms (DMUs), weighing, in some cases, very heavily on the other DMU′s efficiency scores. Thus, it seems that Supplier1 is adequately utilizing all of the specified resources (applying entrepreneurial management) to achieve the best outputs (mean that best in quality, service, flexibility, cost/price and delivery).

Discussion

The overall purpose the study is screening entrepreneurial potentials of automotive manufacturing and performance criteria. Two main points are concern of the study, selection proper criteria and method to achieve the purpose. Regarding to the first point, this study employed entrepreneurial management and performance criteria as indicators. With regard to second point, literature in techniques of supplier selection showed that DEA method is the most useful for ranking the suppliers, among the other method. DEA distinguished seven inefficient suppliers among 12. Some instructions were recommended to improve efficiency of inefficient suppliers. These instructions are related to modifying performance criteria and entrepreneurial management behaviour. Further, DEA identifies a group of efficient suppliers (or peers) that can be employed as templates for boosting efficiency of suppliers.

Table 1: Projection Summary by DEA for DMUs

DMUs	Efficiency	RCI	RCO						Peers
		Input	Output 1	Output 2	Output 3	Output 4	Output 5	
1	1	0	0	0	0	0	0	1
2	0.627	18%	0	14%	0	45%	29%	1, 11
3	0.766	12%	8.5%	22%	0	27%	19%	1, 4
4	1	0	0	0	0	0	0	4
5	1	0	0	0	0	0	0	5
6	0.823	17%	0	4%	3%	0	20%	4, 11
7	0.946	12.5%	20%	2%	0	29%	11%	5, 9
8	0.565	39%	37%	0	23%	0	19%	1, 9
9	1	0	0	0	0	0	0	9
10	0.798	14%	11%	7%	0	4%	14%	1, 5
11	1	0	0	0	0	0	0	11
12	0.913	4%	6.3%	3.5%	0	6%	13%	1, 5, 9

Note: RCI: Recommended Changes for Input; RCO: Recommended Changes for Outputs
Output1: Quality, Output 2: Service, Output 3: Flexibility, Output 4: Price/Cost, Output 5: Delivery

Conclusion

In supply chain management for automotive industry, the nature of supplier selection issue focuses on how to make long term cooperation among different sections in supply chain. Supplier selection is a MCDM which encounters various inputs and outputs. To manage multiple inputs and outputs, this study applied DEA to analyse data. Practically speaking, this study shows a new method to identify inefficient firms and provide them with recommendation on how to improve inputs (entrepreneurial behavior) and outputs, simultaneously.

REFERENCES

[1] Michael H. Hugos, Essentials of supply chain management. Vol. 62. John Wiley & Sons, 2011.

[2] Çebi, Ferhan, and Demet Bayraktar. "An integrated approach for supplier selection." Logistics Information Management 16.6 (2003): 395-400.

[3] A. Amindoust, A. Shamsuddin, A. Saghafinia, "Supplier selection and performance evaluation of telecommunication company." American Journal of Engineering and Applied Sciences 5.1 (2012).

[4] Gary W. Dickson, "An analysis of vendor selection systems and decisions." Journal of purchasing 2.1 (1966).

[5] W. Ho, X. Xiaowei, K. D. Prasanta, "Multi-criteria decision making approaches for supplier evaluation and selection: A literature review." European Journal of Operational Research 202.1 (2010).

[6] Charles A. Weber, "A data envelopment analysis approach to measuring vendor performance." Supply Chain Management: An International Journal 1.1 (1996).

[7] A. Karimi, I. Malekmohamadi, M. A. Daryani, A. Rezvanfar, "A conceptual model of intrapreneurship in the Iranian agricultural extension organization: Implications for HRD." Journal of European Industrial Training 35.7 (2011).

[8] W. B. Liu, D. Q. Zhang, W. Meng, X. X. Li, F. Xu, "A study of DEA models without explicit inputs." Omega 39.5 (2011).

[10] Srinivas. Talluri, "A buyer–seller game model for selection and negotiation of purchasing bids." European Journal of Operational Research 143.1 (2002): 171-180.

[11] S. H. Ghodsypour, C. O'brien, "The total cost of logistics in supplier selection, under conditions of multiple sourcing, multiple criteria and capacity constraint." International Journal of Production Economics 73.1 (2001).

[12] B. Karpak, K. Erdoğan, R. K. Rammohan, "Purchasing materials in the supply chain: managing a multi-objective task." European Journal of Purchasing & Supply Management 7.3 (2001).

[13] V. Wadhwa, A. R. Ravindran, "Vendor selection in outsourcing." Computers & operations research 34.12 (2007).

[14] F. T. S. Chan, H. K. Chan, R. W. L. Ip, and H. C. W. Lau, "A decision support system for supplier selection in the airline industry." Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture 221.4 (2007).

[15] K.L. Choy, W.B. Lee, V. Lo, "A knowledge-based supplier intelligence retrieval system for outsource manufacturing." Knowledge-based systems 18.1 (2005): 1-17.

[16] C. Gencer, G. Didem, "Analytic network process in supplier selection: A case study in an electronic firm." Applied Mathematical Modelling 31.11 (2007).

[17] R. Florez-Lopez, "Strategic supplier selection in the added-value perspective: a CI approach." Information Sciences 177.5 (2007): 1169-1179.

[18] S. H. Huang, K. Harshal, "Comprehensive and configurable metrics for supplier selection." International Journal of Production Economics 105.2 (2007).

[19] H. Ding, B. Lyès, X. Xiaolan, "A simulation optimization methodology for supplier selection problem." International Journal of Computer Integrated Manufacturing 18.2-3 (2005).

[20] Ha, Sung Ho, and Ramayya Krishnan. "A hybrid approach to supplier selection for the maintenance of a competitive supply chain." Expert Systems with Applications 34.2 (2008).

[21] J. Vipul, M. K. Tiwari, and F. T. S. Chan, "Evaluation of the supplier performance using an evolutionary fuzzy-based approach." Journal of Manufacturing Technology Management 15.8 (2004).

[22] C. A.Weber, John Current, Anand Desai, "An optimization approach to determining the number of vendors to employ." Supply Chain Management: An International Journal 5.2 (2000).

[23] Seydel, John. "Supporting the paradigm shift in vendor selection: multicriteria methods for sole-sourcing." Managerial Finance 31.3 (2005): 49-66.

[24] W. W. Cooper, M. S. Lawrence, T. Kaoru, "Data Envelopment Analysis a Comprehensive Text with Models, Applications, References and DEA-Solver Software Second Edition." Springer, (2007).

[25] D. A. Garvin, "Manufacturing strategic planning." California Management Review 35.4 (1993).

[26] H. H. Stevenson, A perspective on entrepreneurship. Harvard Business School, 1983.

[27] R. F. Saen, "Using super-efficiency analysis for ranking suppliers in the presence of volume discount offers." International Journal of Physical Distribution & Logistics Management 38.8 (2008).

[28] T. E. Brown, P. Davidsson, J. Wiklund, "An operationalization of Stevenson's conceptualization of entrepreneurship as opportunity-based firm behavior." Strategic management journal 22.10 (2001).