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Supplier selection in Electrical &Electronic industry from a sustainable point of view

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Abstract: the Malaysian Electrical & Electronic industry (E&E) is an important contributor to the supply chain of business activities around the world. In addition, due to the growth of knowledge on sustainability issues in supply chain management, E&E industry's suppliers as a key component of the chain must have affinity with sustainability issues. So, a real-life supplier selection problem from the E&E industry in Malaysia is considered in this paper. Since, the nature of supplier selection is a multi-criteria decision making problem, this paper applies data envelopments analysis (DEA) to select appropriate suppliers. Sustainable supplier selection factors which derived from literature and interview are considered as inputs and outputs for DEA model.

Keywords: Sustainability, supplier selection, Supply chain management, E&E industry, DEA.

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1. Introduction

One of the most notable paradigms increases the productivity of the firms is managing the supply chains [1-6]. So, a well-structured and applicable supply chain system can be a vital tool for improving the competitive advantages. One of the crucial challenges in supply chain is supplier evaluation and selection. On the other hand, sustainable development has become a buzzword that received a lot of attentions by policy makers, the popular press, and journals in different scientific fields as an interdisciplinary issue. The history of sustainable development concept returns to Brundtland Report of the World Commission on Environment and Development, sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs [7]. During the last two decades, sustainability issue has acquired a dominant place in supply chain and now is being discussed seriously [8-14]. In a study performed by Harwood and Humbly (2008), 20% of the firms viewed sustainability issues as their largest supply chain risk and 25% of the firms required suppliers to adhere to social and ecological standards in order to mitigate supply chain risks [15]. Due to the cost-oriented outsourcing trend over the past decades, external stockholders, such as non-governmental organizations (NGOs) and customers, expect the focal buying firms to assure socially and ecologically sound production at their supplier 'sites. Thus, firms which outsource production to suppliers cannot transfer the risk related to unacceptable environmental and social standards at supplier premises, but must seek active management of the supply base for sustainability [15]. Thereby, sustainable purchasing and sustainable supplier selection will be fertile areas for research. Since the E&E industry is an important contributor to the economy of worldwide business, the supplier selection issue in E&E industry of Malaysian company is considered in this work. Among the extensive range of supplier selection literature in different industries, supplier selection papers in E&E industry which considered sustainability concepts is derived. Then, going through face to face interview with purchasing managers in the mentioned company and considering the aforementioned papers, some supplier selection factors are derived and DEA approach is applied to rank the suppliers.

2. Supplier Selection Factors

The traditional approach to supplier selection has solely considered economic aspects for many years. It is not enough because of globalization in business, competitive market situations, and the changing customers' demands in these days. Organizations must add the environmental/ecological and social aspects to the traditional supplier selection criteria such as quality, cost, delivery, and service to remain in the sustainable supply chain [16]. In this work, 3 existing papers on supplier selection which focused on sustainable issues are chosen as shown in Table 1 to derive the suitable factors.

Table1. Supplier selection researches in electronic industry

Researchers	Evaluation and Selection Factors/Application
Kuo et al., 2010	Quality (reject rate, management commitment to quality, process improvement, warranties and claim policies, quality assurance); Cost (price performance value, compliance with sect oral cost behavior, transportation cost); Delivery (order fulfill rate, lead time, order frequency); Service (responsiveness, stock management, willingness, design capability); Environment (EUP, ODC, RoHS, ISO 14001, WEEE); Corporate social responsibility (the interests and rights of employee, the rights of stakeholder, information disclosure, respect for the policy)/Digital cameras manufacturer
Tseng and Chiu, 2010	Value-adding practices to a firm to ensure the profitability of suppler, Relationship, Delivery reliability, Quality, Satisfy customer needs, Flexibility, Service, Communication, Management, Green design, Environmental certificates, Green production plan, Cleaner production, Green purchasing, Life cycle assessment, Environmental management system, R& D capability, Innovation/ a printed circuit board manufacturer
Yeh and Chuang, 2010)	Production cost, Production time, Transportation cost, Transportation time, Average product quality, Green principles (green image, product recycling, green design, green supply chain management, pollution treatment cost, environment performance assessment)/ Electronic industry

Also some meetings were adjusted to have face to face interviews with experts and staffs of procure activities in one of the E&E industry from Malaysia to derive the vital criteria for supplier selection process. Finally, six criteria in three sustainable groups (economic, environmental, and social) including "cost/price, quality, and delivery" (economic aspects), "Environmental certificates and Green purchasing" (environmental aspects), and "the interests and rights of employee" (social aspects) were considered to select the suppliers.

3. Evaluation and Selection Method

Data Envelopment Analysis (DEA) proposed by Charnes, Cooper, and Rhodes (CCR) (1978) [17] 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. 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 equation (1).

$$MaxZ_k = \sum_{r=1}^{s} u_r y_{rk}$$

st :

$$\sum_{i=1}^{m} v_i x_{ik} = 1 \qquad (1)$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \qquad (j = 1,2,...,n)$$

$$u_r, v_i \ge \varepsilon$$

Where: k is the under evaluation unit; s represents the number of outputs; m represents the number of inputs; is the amount of output r provided by unit j; is the amount of input used by unit ; and are the weights given to output and input respectively[18].

4. Results and Discussion

The data about suppliers for the Malaysian E&E Company is shown in Table 2. In the DEA model, "cost", "quality", and "delivery" criteria were considered as input variables and "Environmental certificates" ," Green purchasing" , and "the interests and rights of employee" as output variables. By applying DEA Excel Solver software considering Table 1 as inputs and outputs data, the efficient and inefficient suppliers are identified as shown in Table 2. Suppliers 5, 7, 8, and 9 are efficient because their efficiency is equal to one but the others which obtained the efficiency less than one are inefficient. In Table2, the optimal weights for inputs and outputs are shown.

Table2. The data for inputs and outputs

Supplier No.	Inputs			Outputs		
	Cost	Quality	Delivery	Environmental certificates	Green purchasing	the interests and rights of employee
1	0.3289	0.5555	0.75	0.9223	0.5723	0.7223
2	0.4552	0.619	0.5	0.9644	0.4832	0.8644
3	0.3783	0.789	0.75	0.9993	0.7693	0.8993
4	0.5633	0.9751	1	0.9923	0.5041	0.9923
5	0.8821	0.539	0.1	0.9642	0.3475	0.9642
6	0.952	0.7344	0.2	0.9728	0.8925	0.9728
7	0.6323	0.321	0.5	0.9342	0.5223	0.9342
8	0.2793	0.299	0.25	0.8662	0.9918	0.8662
9	0.4536	0.498	0.1	0.9384	0.6723	0.7384

Table3. Efficient and inefficient suppliers

Supplier Name	Input-Oriented CRS Efficiency	Optimal Multiplier					
		Cost	Quality	Delivery	Environmental certificates	Green purchasing	The interests and rights of employee
1	0.90419	3.04044	0.00000	0.00000	0.98037	0.00000	0.00000
2	0.68314	2.19684	0.00000	0.00000	0.70835	0.00000	0.00000
3	0.85175	2.64340	0.00000	0.00000	0.85235	0.00000	0.00000
4	0.56801	1.77525	0.00000	0.00000	0.57242	0.00000	0.00000
5	1.00000	0.54652	0.00000	5.17915	0.00000	0.00000	1.03713
6	0.79568	0.00000	0.78349	2.12301	0.00000	0.28680	0.55480
7	1.00000	0.01374	3.08821	0.00000	0.00000	0.00000	1.07043
8	1.00000	0.00000	3.34448	0.00000	0.00000	0.00900	1.14416
9	1.00000	0.00000	1.66696	1.69856	1.06564	0.00000	0.00000

4. Conclusions

Fierce competitiveness in E&E global marketing exerts pressure on enterprises to provide their products to customers faster, cheaper, and better than the competitors. To do these, selection of appropriate suppliers is very important issue in supply chain management of E&E industries. In addition, the sustainability issues have become other important dimension in supply chain management owing to the importance of environmental protection and social merits. In this paper, the sustainable supplier selection criteria through literature and interviews with procurement teams of one of the E&E industry in Malaysia were derive to benefit all other similar industries worldwide. Then the DEA model as a multi-criteria decision making method was applied to determine the efficient and inefficient suppliers.

Conflict of Interest

The authors declare no conflict of interest.

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