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LOCATION DECISION OF SUPPLY CHAIN MANAGEMENT IN THE AUTO MOTIVE INDUSTRY

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ABSTRACT
Plant location decision as a start point to success the supply chain of firms have been received more attention today. One of the Malaysian automotive industries which intend to find a location to extend its company is considered in this study. Since, the location decision involves multiple criteria the appropriate tools must be applied to solve this issue. So, this paper applies data envelopment analysis (DEA) to select appropriate location and the selection criteria which derived from literature and interviews are considered as inputs and outputs for DEA model.

Keywords: Supply chain, location decision, automotive industry, DEA

1. INTRODUCTION

Due to the recent agile improvement of network technology and economic globalization, supply chain management (SCM) has come to play a critical role as a key to business activities [1]. One of the most important and far reaching decisions in SCM faced by operations managers is deciding where to locate new manufacturing facilities. This is a strategic decision involving irreversible allocation of the firm's capital, and often has a crucial impact on key measures of the firm's supply chain performance such as lead time, inventory, and responsiveness to demand variability, flexibility, and quality. With the emergence of efficient supply chain management as an important frontier of competition, the facility location decision becomes even more significant.

Centrally located in the ASEAN region with a population of more than 500 million people, Malaysia offers vast opportunities for global automotive and component manufacturers to set up manufacturing and distribution operations in the country. Pragmatic government policies, political and economic stability, sound economic fundamentals, well developed infrastructural facilities and an educated and skilled labor force have attracted major international automotive and component manufacturers to invest in Malaysia.

This paper is organized to determine the location selection criteria through literature and face to face interviews with operation managers. Then, a DEA model is suggested using those criteria onto selecting the best locations.

2. LOCATION SELECTION CRITERIA IN AUTOMOTIVE INDUSTRY

Going through location decision literature, the most popular criteria on this issue are determined. These criteria are including Cost, Infrastructure, Business services, Labour, Government, Customer/market, Supplier/resources, and Competitors [2-8].

In this work, some meetings were adjusted to have face to face interviews with experts and staffs of operation management team in automotive industry to derive the vital criteria for location selection process. It is worthy to say that Infrastructure, Competitor, and Customer/market are omitted in these meetings and receive no attention. So, the remained five criteria were considered to select the best locations. For more clearance about applied selection criteria, some explanation is prepared as below.

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- Cost: cost of land, transportation, and energy
- Business service: availability of air and sea freight services and land transport service
- Labour: knowledge workers, foreign workers, expert and education level, and productivity
- Government: tax policies, governmental support, protection of foreign investment
- Supplier/resources: availability of suppliers

3. EVALUATION AND SELECTION METHOD

Data Envelopment Analysis (DEA) proposed by Charnes, Cooper, and Rhodes (CCR) (1978) [9] 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 [10].

In location decision, the efficiency of a location is calculated using the ratio of weighted outputs to weighted inputs. The goal of the firm is to choose one or more locations from n candidates. In order to calculate the set of efficiencies for n locations, n fractional programming models are solved. The problem can be changed into linear programming. The model for location k could be defined as follows equation (1).

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

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"; x_{ij} is the amount of input i used by unit j; u_r and v_i are the weights given to output r and input i respectively[10].

4. RESULT AND DISCUSSION

The list of locations for automotive industry in Malaysia and the information about them is shown in Table 1. In the DEA model, "cost", and "government" criteria were considered as input variables and "business service" ,"labour" , and "supplier/resources" as output variables.

By applying DEA Excel Solver software considering Table 1 as inputs and outputs data, the efficient and inefficient locations are identified as shown in Table 2. Locations 7 and 8 are efficient (appropraite) because their efficiency is equal to one but the others which obtained the efficiency less than one are inefficient (inappropraite).

In Table2, 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 Table3.

5. CONCLUSION

Fierce competitiveness in global markets exerts pressure on enterprises to rethink about supply chains. To do these, selection of appropriate location is very important issue in supply chain management and actually a start point to success the supply chains.

In this paper, the Malaysian automotive industry is considered as a case study. First, location selection criteria were derive through literature and interviews with operation managers of the mentioned company to benefit all other automotive industries worldwide. Then the DEA model as a multi-criteria decision making method was applied to determine the efficient and inefficient locations and calculate the target value for inputs and outputs.

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Table 1. The data for inputs and outputs

Location No.	Inputs		Outputs		
	Cost	government	business service	labour	supplier/resources
1	0.3289	0.5555	0.5723	0.7223	0.9223
2	0.4552	0.619	0.4832	0.8644	0.9644
3	0.3783	0.789	0.7693	0.8993	0.9993
4	0.5633	0.9751	0.5041	0.9923	0.9923
5	0.8821	0.539	0.3475	0.9642	0.9642
6	0.952	0.7344	0.8925	0.9728	0.9728
7	0.6323	0.321	0.5223	0.9342	0.9342
8	0.2793	0.299	0.9918	0.8662	0.8662
9	0.4536	0.498	0.6723	0.7384	0.9384

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Table 1. Appropriate and inappropriate locations

Location No.	Input-Oriented CRS Efficiency	Inputs		Outputs		
		Cost	government	business service	labour	supplier/resources
1	0.90419	3.04044	0.00000	0.00000	0.00000	0.98037
2	0.68314	2.19684	0.00000	0.00000	0.00000	0.70835
3	0.85175	2.64340	0.00000	0.00000	0.00000	0.85235
4	0.56801	1.77525	0.00000	0.00000	0.57242	0.00000
5	0.61558	0.00819	1.84188	0.00000	0.00000	0.63843
6	0.45651	0.00602	1.35385	0.00000	0.46927	0.00000
7	1.00000	0.00000	3.11526	0.00000	0.00000	1.07043
8	1.00000	0.00000	3.34448	1.00827	0.00000	0.00000
9	0.66706	2.20459	0.00000	0.00000	0.00000	0.71085

Table 2. Target inputs and outputs

Loaction No.	Cost	government	business service	labour	supplier/resources
1	0.29739	0.31836	1.05603	0.92230	0.92230
2	0.31096	0.33290	1.10424	0.96440	0.96440
3	0.32222	0.34494	1.14420	0.99930	0.99930
4	0.31996	0.34253	1.13618	0.99230	0.99230
5	0.54300	0.33180	0.72028	0.96420	0.96420
6	0.43459	0.33526	0.91394	0.97280	0.97280
7	0.63230	0.32100	0.52230	0.93420	0.93420
8	0.27930	0.29900	0.99180	0.86620	0.86620
9	0.30258	0.32392	1.07447	0.93840	0.93840