TECHNICAL EFFICIENCY OF DATA ENVELOPMENT ANALYSIS: AN APPLICATION IN ROAD FREIGHT TRANSPORTATION

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Abstract

Road freight transport is main medium for land mode distribution in Malaysia. Its road network covers 98,721 kilometres includes 1821 kilometres of expressway. In such way, key determinant to create and distribute good is much towards road. Government initiative in creating regional economic development has spur supply chain process in Malaysia. Albeit, East Coast Economic Region (ECER) that consists Pahang, Terengganu and Kelantan are move towards to the aim. The aim of this research is to measure road freight transport efficiency within ECER. A non-parametric technique is used for data analysis. By having this, the result is attempts to indicate which state is most efficient from the input and output allocated. Apart from that, this research investigates relationship between road freight transport activity and supply chain management within ECER.

Keywords*: Road transport, Efficiency, Supply Chain, Data Envelopment Analysis*

Introduction

Road freight cargo distribution is economic catalyst for transportation activities. The study between transport and urban form are being discussed by many researchers that concerned on passenger transport (Banister, 2005; Breheny, 2001; ECOTEC, 1993; Newman and Kenworthy, 1988; Stead and Marshall, 2001; Taylor and Sloman, 2008). However, the study of freight transport and logistics remains relatively under researched (Hesse and Rodrigue, 2004; Rodrigue, 2006). These have created imbalance gap between passenger and freight transport research (Allen et al. 2012). The significant contribution of this area does not portray with studies that have been conducted. Hence, less study on freight distribution instead of passenger represent the importance of this study. Therefore, the aim of this study is to investigate the efficiency of road freight distribution towards economic development within the study area. The preliminary finding of this research is focus on the expected contribution of road efficiency of freight distribution.

This paper breaks into sections which are introduction, previous studies on supply chain and road efficiency. Then, follow with research methodology, results and discussions and the last is conclusion.

Related studies on supply chain and road efficiency

Freight cargo distributions have a single purpose of transporting goods from one point to another in supply chain process. At the point of supply chain process, goods are distributed,

stored, or sold. The decisions process of these freight distributions are made by the owners or consignees, the customers, and the transporters or consignors. The freight cargo distributions are influenced by internal and external factors such as size, density and layout of areas of cargo to be distributed. The other influence options such as less modal options for freight, demand for freight transport is inelastic with freight charge and freight cargo distributions are follow major roads.

Therefore, freight cargo distributions are following the demand from users. This has derived the demand pattern for freight distribution as focus on the settlement size, density, commercial areas, industrial areas and land use. Hence, demand and road network determine supply chain network demand are available with facilities such as warehousing facilities, logistics, order processing, material handling and transportation are in order. Cherrett et al (2009) interpret the operating pattern and types of vehicles used are necessary for urban freight cargo distribution.

Research Methodology

Area of Study

East Cost Economic Region (ECER) inception in 2008 which consists of Pahang, Terengganu and Kelantan. There are five economic clusters that are key drivers, namely Tourism, Oil, Gas & Petrochemical, Manufacturing, Agriculture and Education. On top of these, the fundamental section where able to boost key drivers is transportation sector. Allen et al, (2012) state that there has been no comparable consideration of the interactions between the various features of urban areas and freight transport activity. This work focuses on road freight transport activity as the pillar of economic activity in ECER area. Figure 1.0 depicts the area of work under Pahang, Terengganu and Kelantan road freight transport activity.

Figure 1.0: Area of research

Taking into consideration government initiative to develop Pahang, Terengganu and Kelantan under ECER, this research focuses on the freight transport activity where less researches are being conducted in measuring road freight transport efficiency within ECER.

Analysis Technique by Using Data Envelopment Analysis

There are two categories of technique for data analysis; parametric and non-parametric. This research is using non parametric technique that is Data Envelopment Analysis (DEA) as main data analysis. Nonparametric techniques do not require a pre-defined functional formulation but use liner programming techniques to determine rather than estimate the efficiency frontier. The rationale of using DEA is each Decision Making Unit (DMU) is allowed to set a combination of weights that shows it in the most favorable position vis-à-vis other DMUs.

The description of input and output for this research are based on availability of data. The preliminary analysis is gathered data from authorities such as Public Work Department, Road Transport Department and Custom. Hence, the reliability of data is derived from statistical department of respective authorities. Table 1.0 represents input and output of study.

Table 1.0: Selection Input and Output

Inputs	Output
X1: Federal Road (Fed Rd)	Y1: Revenue (R)
X2: State Road (State Rd)	
X3: Highway (Hway)	
X4: Cargo Fleet (CF)	

The data is conducted for preliminary finding as some of the authorities are not responded as researcher request for data. The methodology is still follow DEA technique for analysis for certain benefits of using this technique. As a deterministic, the results that are normally sensitive to measurement error. DEA only measures efficiency relative to best practice within the particular sample. Thus, it is not meaningful to compare the scores between two different studies. DEA scores are sensitive to input and output specification and the size of the sample. Despite these limitations, data envelopment analysis is a useful tool for examining the efficiency of government service providers.

The principles are similar to measure efficiency of Decision Making Unit (DMU). Charnes et al. (1978) present a solution algorithm for the problem posed by Farrell (1957) and called as DEA-CCR (Charnes, Cooper and Rhodes). The following model purposed by Charnes et al. (1978):

$$\max \quad \frac{\sum_{k=1}^{s} u_k y_{kp}}{\sum_{j=1}^{m} v_i x_{ip}}$$

$$\text{s.t} = \frac{\sum_{k=1}^{s} u_k y_{ki}}{\sum_{j=1}^{m} v_j x_{ji}} \leq 1, \forall i, \text{ and } u_k v_j \geq 0 \; \forall k, \; j$$

Where k=1 to s;

J =1 to m 1, and j =1 to n

` y_{ki} = amount of output k produced by DMUi

x_{ji} = amount of input j utilised by DMUi

u_k = weight given to output k

v_j = weight given to input j

Results and discussions

Descriptive analysis

Table 2.0 depicts correlation of input and output for this research. Between input and output there are positive and negative correlations. The strong and weak correlation represent positive and negative for the research. As the raw data are not normal, the correlation of input and output do not jeopardise the analysis for this research.

Table 2.0: Correlation of input and output

Fed Rd	1				
State Rd	0.314008	1			
Hway	0.367726	-0.76743	1		
cargo fleet	0.947776	0.597769	0.054523	1	
revenue	0.685632	-0.463057	0.916554	0.42788	1

Each of the input and output represent maximum, minimum, average and standard deviation of input and output. Table 3.0 depicts statistical analysis for input and output of DMUs. Being not normal data each of input and output represent variety of scale. Nevertheless, this does not mean that the statistical finding is error. However, the big scale is reflecting score data for each DMU.

Table 3.0: Statistic data for input and output

	Fed Rd	**State Rd**	**Hway**	**cargo fleet**	**revenue**
Max	3745	15901	190	40365	858128667
Min	1259	5598	0	20013	48185044.9
Average	2088	11734.33	116.6667	28830.5	519063616
Sd	1171.676	4430.774	83.39997	8205.814	307085781

The ranking order which represent efficient and inefficient result reflects DMU in which represent efficiency of study. The score analysis which based on the slack represents inefficient excess of Phg2011 (0.917) of federal road by 111.9 km and state road by 375.1 km. It depicts the unutilised federal road of Phg2011, 111.9 km of 3745 km. Similar with state road, the unutilised of 375.1 km do not represent state road by 13704 km. Inefficient for Tgg2012 with score 0.908 with slack excess by cargo fleet by 260.69 km. The inefficient results for Kel2011 (0.316) represent situation slack excess of federal road and state road by 6.8 km and 85.39 km respectively.

Table 4.0: Score ranking of DMUs

DEA-CCR			
No.	DMU	Score	Rank
1	Kel2012	1	1
2	Phg2012	1	1
3	Tgg2011	1	1
4	Phg2011	0.917783	4
5	Tgg2012	0.908351	5
6	Kel2011	0.316908	6

Figure 1.0 depicts efficient and inefficient DMU from CCR input. There are 3 DMU which represent efficient output = 1 (Kel2012, Phg2012 and Tgg2011). From the results of respective efficient DMUs, it shows that between input and output data given, that states are able to utilise resources available with revenue obtain. However, inefficient DMUs (Phg2011, Kel2011 and Tgg2012) show that inefficient distribution resources between input and output obtain. The underutilised of resources for DMU Kel2011 shows that output (revenue) derived is lesser than facilities available

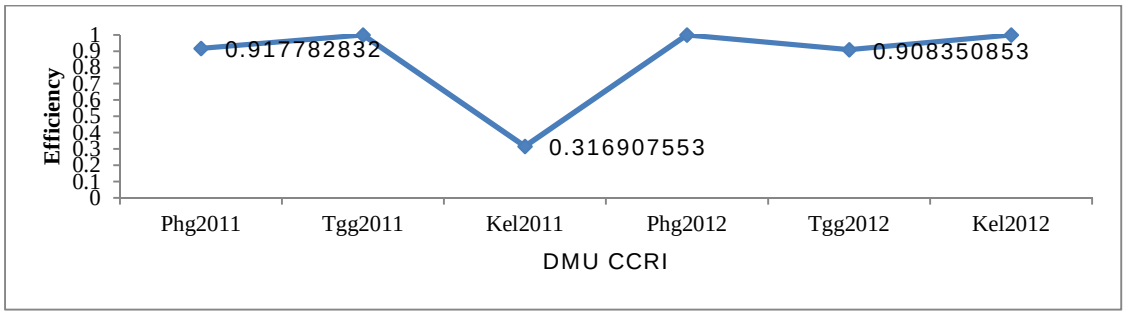

Figure 1.0: Efficiency score for DMUs

Conclusions

The research shows that a good sign of road transport efficiency for ECER. However, preliminary finding does not portray real situation researchers are unable to gather data from authorities. Nevertheless, the preliminary finding indicates relationship between input and output do trigger on efficiency of transportation sector towards ECER. Therefore, additional data are required in order to foresee the activities that can contribute to the research.

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