Volume 6• Number 2 • July - December 2013 DOI: http://dx.doi.org/10.12660/joscmv6n2p1-19

Technical Efficiency of Container Terminal Operations: a Dea Approach

Kasypi Mokhtar
University Malaysia Terengganu
m.kasypi@yahoo.com

ABSTRACT: Nowadays, transporting cargoes via container are key indicator for every shipment. The movement of container involves multi modes to reach destination. The efficient transport networking systems are determinant attribute towards container terminal in providing excellent services to their client. The paper focuses on the metamorphosis of the terminal efficiency and container movements at 6 major container terminals in Peninsular Malaysia. The aim is to measure efficiency of container terminals that contributes significant economic development for a nation. Non parametric approach under frontier method is used to analyse panel data from 2003 to 2010 in relation with container terminal equipments and throughput. The result shows no significant relationship between container terminal size and efficiency. Thus, efficiency is determined from allocation of resources efficiently by terminal operators and not by size of terminals.

Keywords*: Technical efficiency, Container terminal, Data envelopment analysis, Transportation*

The research is financed by Ministry of Higher Education under Fundamental Research Grant

1. INTRODUCTION

Since the invention of container by Malcom Mclean late 1950s, and the first international shipment in 1966, the shipments of goods have changed drastically (Levinson, 2006). In addition, containerisation is applied to all modes of transport such as rail, container vessel and haulage. The handling process of moving of goods continuously improved, and it has benefited to all parties. Containerisation and the development of intermodal transports system have had a profound effect on the shipping industry, its structure, management and operation. The movement of goods in a single container by more than one mode of transportation was an important development in the transportation industry and all the elements involved for the international and domestic trade. Classically, the terms 'Through Transport', 'Combined transport', 'Intermodal transport', and 'Multimodal transport' are preferable for movement of goods. It started from the point of origin to point of destination. These four terms have very similar meaning, where the movements of goods are involved with more than one mode to ship the cargo (UNCTAD, 1993; 2001). Multimodality or intermodality has given tremendous impact to the transport industry (Hayuth, 1987; Hariharan, 2002; Levinson, 2006).

Intermodality is defined as the movement of cargo from shipper to consignee by at least two different modes of transport under a single rate, through-billing and through-liability (Hayuth, 1987). Multimodal transport refers to a transport system usually operated by one carrier with more than one mode of transport under the control or ownership of one operator. It involves the use of more than one means of transport i.e., truck, railcar, aeroplane or ship in succession to each other e.g. a container line which operates both a ship and a rail system of double stack trains (UNCTAD, 1993; 2001). The objective of these concepts is to transport goods from point of origin to point of final destination in the most cost and time effective. Therefore, to achieve the objective of multimodalism, intensive cooperation and coordination among transportation modes are essential. The paper studies the container terminal efficiency from where transportation network systems generate container from and to container terminal.

The study covers 6 major container terminals in Peninsular Malaysia. The non parameter technique under frontier method called as data envelopment analysis (DEA) is used to analyse panel data from 2003 to 2010. The first section starts with introduction and follows with theoretical perspective on transportation systems in section 2. Under section 3, discussion on the efficiency technique and DEA model is developed for the research. Section 4 discusses DEA that has been applied at container terminal. Furthermore, the model is applied for this research to analyse the panel data. Section 5 represents results and discussion on the analysis from DEA-CCR and DEA-BCC output-oriented. In Section 6 represents conclusion on the research.

2. THEORETICAL PERSPECTIVE: CONTAINERISATION AND TRANSPORTATION NETWORK

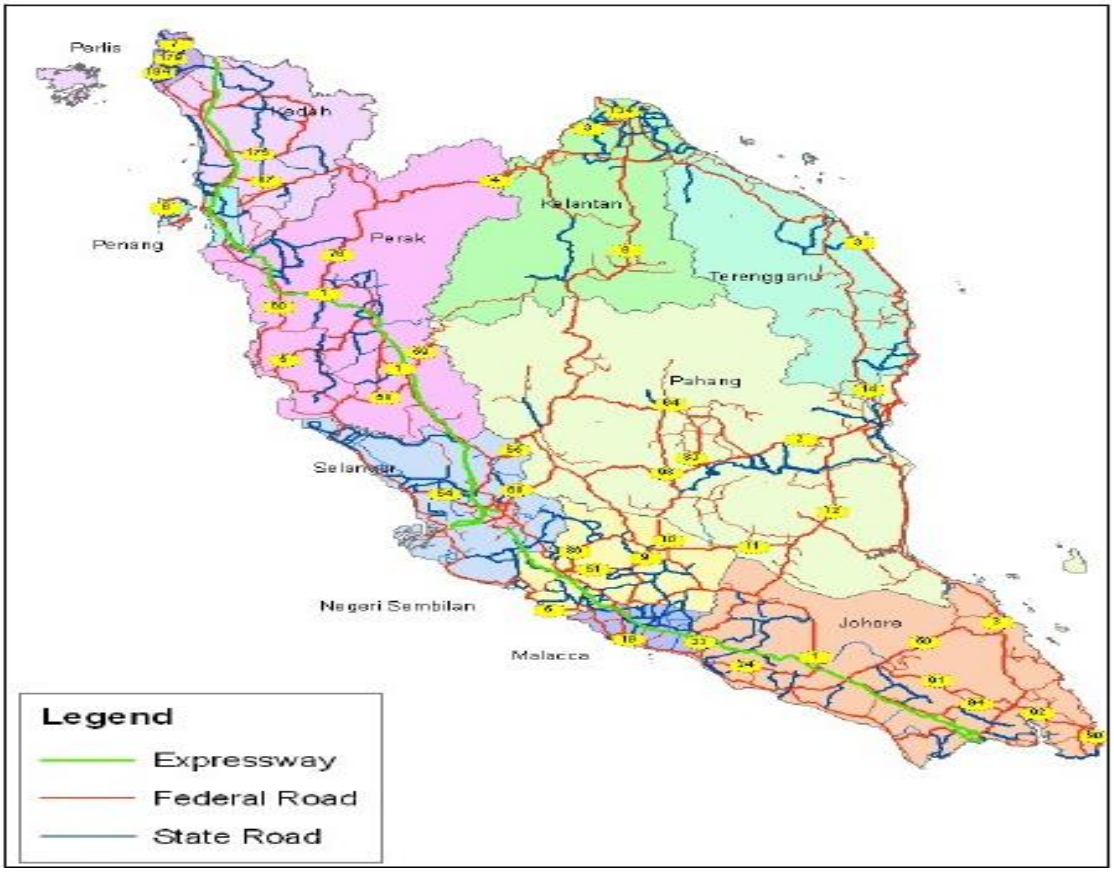
Back in 1955, delivery process has been changed when Malcom Mclean introduced standardised container box (UNCTAD, 1993; 2001; Levinson, 2006). The first shipment by using container took place in Newark, New Jersey USA where shipment of cargoes to Puerto Rico of a Sea-Land vessel. However, Sea-Land international maiden only happened in 1966 because of confrontations with shipping lines (Talley, 2000; Levinson, 2006). First international called for Sea-Land was to Rotterdam, and since that time; the new era of shipping industry has emerged with the international trade via container. The container revolution has been improved with the general introduction of twenty footer and forty footer standardised container or International Organisation for Standardisation (ISO) container. The invention of containerised cargo means it is able to load and be secured on a truck chassis, a rail car, or in vessel's hole or deck.

Generally, intermodalism terminology is being since 1920s, however intermodalism freight transportation officially used in 1985 (UNCTAD, 1993; 2001). In addition, multimodal transport was officially introduced in 1980 when United Nation sponsored Multimodal Convention, the term attained legal recognition on 1st January 1992 when 1992 UNCTAD/ICC Rules for Multimodal Transport was launched (UNCTAD, 1993; 2001). Since then, the movement of container from point of origin to point of destination by using different type of mode became commercially feasible to the industry.

An efficient and good road networks are main catalyst for movement of good via road (World Bank,

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

2005). The road networks are accessible throughout Peninsular Malaysia and contribute significant towards state economic development. The accessibility has spurred development of container terminal in Peninsular Malaysia. Its locations are in Penang (Penang Port), Selangor (Westport and Northport), Johor (Johor Port and Tanjung Pelepas Port) and Pahang (Kuantan Port). Hayuth (1987, 1994) emphasis that integrated logistic network is important for movement of container via road. Figure 1 depicts road network in Peninsular Malaysia. The road network consists of expressway, federal and state road. In Peninsular Malaysia, total road network systems are 82144 kilometre (PWD, 2009). The road breakdowns are 61420 km

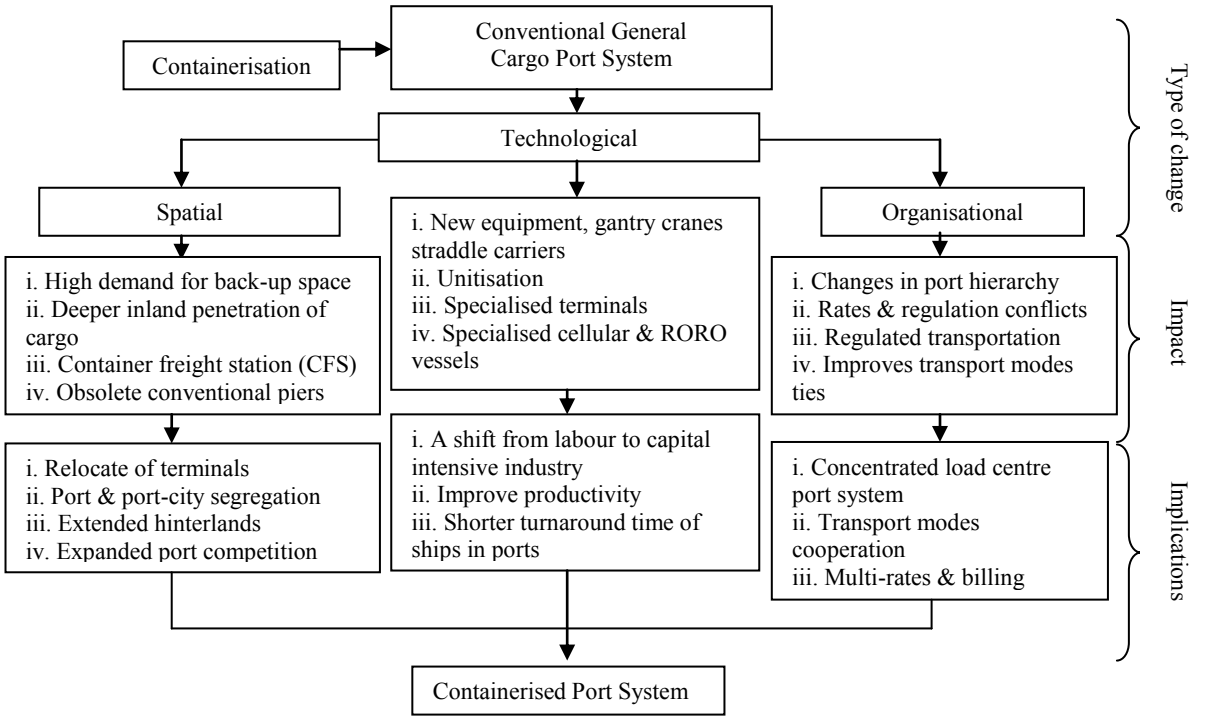


under state and municipality roads, 18904 km under federal roads and 1820 km are toll highways (PWD, 2009; Levinson and Zhu, 2011).

Figure 1. Major Road Network in Peninsular Malaysia (PWD, 2009

Figure 2 depicts the impact and transformation from conventional to container on the containerised port system. It was manifested into two impacts which are spatial and organisational. With the introduction of con-

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19



tainer system, the port process has been changed drastically from the equipments, manpower, port system and port's charges. This transformation has classified terminal more organised even though the process becoming more complex. However, by having an organised structure container terminal operation is able to handle efficiently.

Figure 2. The impact of containerisation on the conventional general cargo port system (Hayuth, 1987)

A terminal involves a lot of parties from government agencies, shipping agents, forwarding agents, carriers, ship owners, container terminal operators and clients. Even a console good inside container will through similar process for documentation, handling rate, custom clearance, and shipment. Containerisation is the largest form of unitisation. Containers are loaded with products at the shipper's premises and sealed, and then they are carried over to the consignee's premises intact, without the content being taken out or re-packed en route.

This is the essence of container transport as well as multimodal transport, but containerisation is not synonymous with multimodal transport. Containerisation contributes to a higher efficiency in the development of multimodal transport operations. The focus, now, is more on the organisation of the transport industry and the synchronisation of the integrated logistical system (Hayuth, 1987; Carrese and Tatarelli, 2011; Kasypi *et al*, 2013). In order to achieve multimodal transport, intensive co-operation and co-ordination among transport modes are essential.

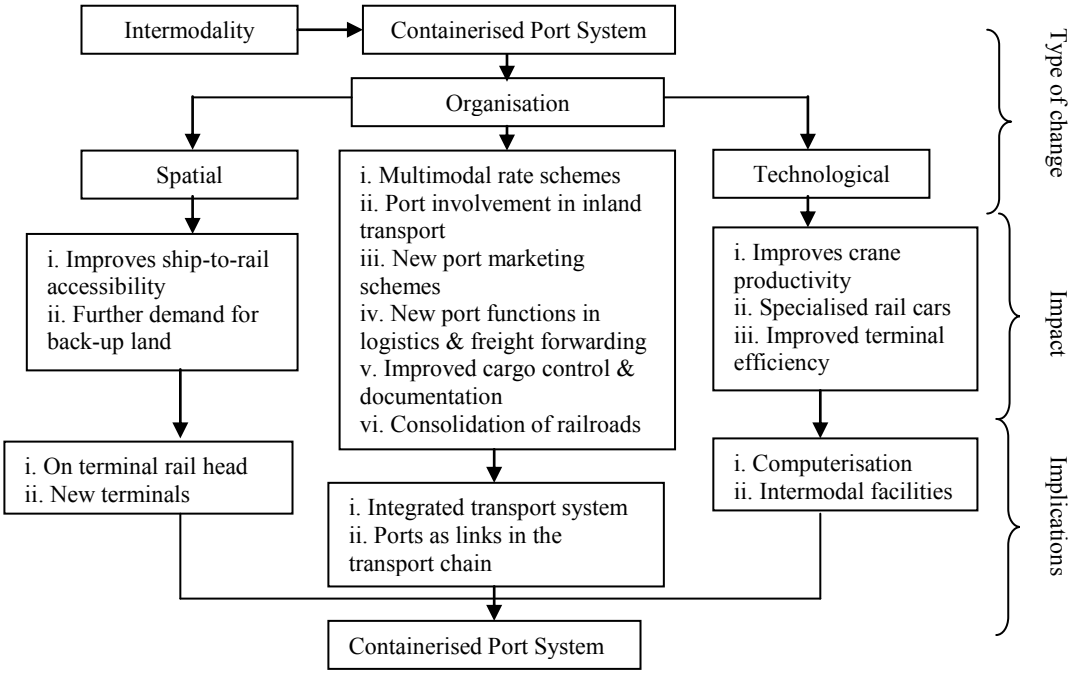
Kasypi and Shah (2012) establish the integration model of container terminal by applying IDEF0 with

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

supply chain. The model integrates gate, yard, wharf and vessel components at container terminal in enhancing the operational activity. The IDEF0 lean supply chain model is a mapping process for movement of containers from and to vessel as well as gate in and out. The mapping model is able to monitor and execute operational process in maximising efficiency and productivity. Figure 3 depicts the IDEF0 model for container terminal.

Figure 3. IDEF0 Model for Container Terminal (Kasypi and Shah, 2012)

Figure 4 shows the impact of intermodal transport on the containerized port system. During those days,



there are two phases of transformation of containerized port system. The first phase of port containerization involved a period of technological change and a massive growth in the spatial dimensions of terminals. For the

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

second phase, its focuses attention on organizational aspects of international transport and the port industry i.e., marketing strategies, participation by ports in the physical distribution of cargo. Thus, in this phase the containerized port system is an integrated transport system

Figure 4. The impact of intermodal transport on the containerized port system. (Hayuth, 1987)

3. EFFICIENCY TECHNIQUE: DATA ENVELOPMENT ANALYSIS

Efficiency is derived and part of productivity, where it is a ratio of actual output attained to standard output expected (Sumanth, 1984). Mali (1978) express together the terms productivity, effectiveness and efficiency as follows:

$$\text{Productivity index} = \frac{\text{output obtained}}{\text{input expected}} = \frac{\text{performance achieved}}{\text{resources consumed}} = \frac{\text{effectiveness}}{\text{efficiency}} \quad (1\text{-}0)$$

Therefore, Sumanth (1984) and Ramanathan (2003) express efficiency as follow:

$$Efficiency = \frac{Output}{Input} \quad (2\text{-}0)$$

The (2-0) equation is applicable for evaluation of simple data. The entity of output and input are diverse significantly. Therefore, equation (2-0) is not suitable for complex relationship between outputs and inputs. The weight cost approach is the solution for complexities of outputs and inputs as follows:

$$Efficiency = \frac{\sum weighted\ of\ outputs}{\sum weighted\ of\ inputs} \quad (3\text{-}0)$$

By assuming all weights are uniform, mathematically equation is expressed as follows:

$$Efficiency = \frac{\sum_{r=1}^{n} u_r y_r}{\sum_{s=1}^{n} v_s x_s} \quad (4\text{-}0)$$

Where;

y_r = quantity of output r

u_r = weight attached to output r

x_s = quantity of input s

v_s = weight attached to input s

An efficient has value = 1, therefore, to classify unit of efficiency is set as $0 \leq$ Efficiency ≤ 1.

3.1 Technical Efficiency: Data Envelopment Analysis

Technical efficiency (TE) is described as the conversion of physical inputs (such as the services of employees and machines) into outputs relative to best practice. In other words, given current technology, there is no wastage of inputs whatsoever in producing the given quantity of output. An organization operating at best practice is said to be 100% technically efficient. If operating below best practice levels, then the organization's technical efficiency is expressed as a percentage of best practice. Managerial practices and the scale or size of operations affect technical efficiency, which is based on engineering relationships but not on prices and costs.

Data Envelopment Analysis (DEA), first introduced by Charnes, Cooper and Rhodes (CCR) in 1978 (Charnes et al, 1978), extended Farrell's (1957) idea of estimating technical efficiency with respect to a production frontier. The definition of efficiency is referred from the "Extended Pareto-Koopmans" and "Relative Efficiency" The CCR is able to calculate the relative technical efficiency of similar Decision Making Units (DMU) through the analysis, with the constant returns to scale basis. This is achieved by constructing the ratio of a weighted sum of outputs to a weighted sum of inputs, where the weights for both the inputs and outputs are selected so that the relative efficiencies of the DMUs are maximized with the constraint that no DMU can have a relative efficiency score greater than one. On the other hand, the DEA-BCC model (Banker et al., 1984) extend from DEA-CCR by assuming variable returns to scale where performance is bounded by a piece-

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

wise linear frontier. There are other DEA models in the literature, but DEA-CCR and DEA-BCC are the most commonly used models.

There are numerous articles, journals and books published about DEA since 1978, with numerous extensions of the methodology and many novel applications (Seiford and Thrall, 1990 and Seiford, 1994). Since the CCR (1978), the development has introduced the BCC model that is Banker, Charnes and Cooper in 1984 (Barnes et al, 1984). The BCC model relaxes the convexity constraint imposed in the CCR model which allows for the efficiency measurement of DMUs on a variable returns to scale basis. The BCC model results in an aggregate measure of technical and scale efficiency, the CCR model is only capable of measuring technical efficiency. This allows for the separation of the two efficiency measures.

The scale efficiency measurement indicates whether a DMU is operating at the most efficient scale, while technical efficiency is a measure of how well the DMU is allocating its resources to maximize its output generation. It is important to note that the BCC model is both scale and translation invariant, while the CCR model is only scale variant. The development of the Additive model, which involves reduction of inputs with a simultaneous increase in outputs, and Multiplicative models note worthy advances which, along with further explanations of the DEA technique and its extensions, are outlined in (Ali and Seiford, 1993, Charnes et al, 1994a, Charnes et al, 1994b and Lovell, 1993). Since the first application of DEA for measuring the efficiency of business student to schools (Chanrnes et al, 1978) the technique has been applied in over 50 industries i.e., healthcare, transportation, hotel, education, computer industry etc.

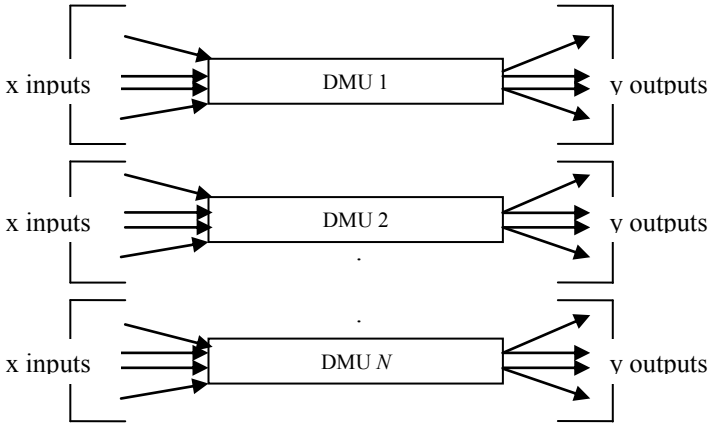
3.1.2 Model Development

The model is developed from the extension of the ratio technique used in traditional efficiency approaches. The measurement is obtained from DMU as the maximum of a ratio weighted output to weighted input. The numbers of DMUs are not determined outputs and inputs, however, larger DMUs are able to capture higher performance. This would determine the efficiency frontier (Golany and Roll, 1989). In addition, the number of DMUs should be at least twice the number of inputs and outputs (Golany and Roll, 1989).

The parameters and variables are needed in developing the model. Therefore, the model is based on the following parameters and variables:

N = number of DMU $\{j = 1,2,...n\}$

y = number of outputs $\{y = 1,2,...R\}$



x = number of inputs $\{x = 1,2,...S\}$

y_i = Quantity of output r^{th} of output of j^{th} DMU

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

x_i = Quantity of input s^{th} of input of j^{th} DMU

u_r = weight of r^{th} output

v_s = weight of s^{th} input

Figure 5: DMU and Homogeneous units

Golany and Roll (1989) describe that homogenous unit is important in choosing DMUs to be compared and identifying the factors affecting DMUs. Therefore, homogenous group of units need to perform similar task and objectives, under same set of market conditions and the factors (inputs and outputs). Figure 5 depicts the DMU and homogeneous units.

This concept is using linear programming (LP) formulation to compare the relative efficiency of a set of decision making units (DMUs). Farrell (1957) has developed similar approach to compare the relative efficiency of a cross-section sample of agricultural farms.

The efficiency measures under constant returns to scale (CRS) are obtained by *N* linear programming problems under Charnes *et al*. 1978 as below:

$$
\begin{aligned}
&Min_{\psi,\lambda}\ \psi_j \\
&\sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j; \quad r = 1,...,R \\
&\sum_{i=1}^{N} \lambda_i x_{si} \leq \psi_j x_j; \quad s = 1,...,S \\
&\lambda_i \geq 0; \quad \forall i
\end{aligned}
\tag{3-0}
$$

Where $y_i = (y_{1i}, y_{2i}, ..., y_{Ri})$ is the output vector, $x_i = (x_{1i}, x_{2i}, ..., x_{si})$ is the input vector. Solving above equation for each one of the *N* container terminals of the sample, *N* weights and *N* optimum solution found. Each optimum solution ψ_j^* is the efficiency indicator of container terminal j and, by construction satisfies $\psi_j^* \leq 1$. Those container terminals with $\psi_j^* < 1$ are considered inefficient and $\psi_j^* = 1$ are efficient. Charnes *et al*. (1978) model constant returns to scale (CRS) was modified by Banker *et al* (1984) by adding the restriction $\sum_{i=1}^{N} \ddot{e}_i = 1$, this has generalising model to variable returns to scale (VRS) as below;

$$
\begin{aligned}
&Min_{\vartheta,\lambda}\ \vartheta_j \\
&\sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j; \quad r = 1,...,R \\
&\sum_{i=1}^{N} \lambda_i x_{si} \leq \vartheta_j x_j; \quad s = 1,...,S \\
&\sum_{i=1}^{N} \lambda_i = 1; \lambda_i \geq 0; \quad \forall i
\end{aligned}
\tag{4-0}
$$

Charnes et al. (1978) from DEA-CCR discover the objective evaluation of overall efficiency and identify the resources and estimates the amounts of the identified inefficiencies. Thus it is called constant return to scale (CRS). Albeit, Banker et al, (1984), DEA-BCC remove the constraint from the CCR model by adding $\sum_{i=1}^{N} \ddot{e}_i = 1$ thus, BCC is able to distinguish between technical and scale inefficiencies by (i) estimating pure technical efficiency at the given scale of operation and (ii) identifying whether increasing, decreasing or constant return to scale possibilities are present for further exploitation. It is called as variable return to scale. Therefore, for CCR efficient is required both scale and technical efficient, BCC efficient is only required technically efficient.

4. CONTAINER TERMINAL EFFICIENCY USING DATA ENVELOPMENT ANALYSIS

A firm's productivity is usually measured by comparing its actual production volume with a production frontier. Wang et al. (2005), productivity measurement can be classified into using a parametric frontier approach or a non-parametric frontier approach. In the parametric frontier approach, the productivity frontier is estimated in a particular functional form with constant parameters. Liu (1995) uses a stochastic parametric frontier approach on 25 world ports, whereas Estache et al. (2001) studies 14 Mexican ports in order to investigate the efficiencies gained after port reform. Other studies on port performance with a stochastic parametric frontier approach are Tongzon and Heng (2005), Cullinane and Song (2003), Cullinane et al. (2002) and Notteboom et al. (2000). Besides this, Coto-Millan et al. (2000) uses a stochastic cost function approach on 27 Spanish ports. De and Ghosh (2002) examined 12 Indian ports using a time-varying production function approach. On the other hand, the non-parametric frontier approach assumes no particular functional form for the frontier. The most commonly used non-parametric frontier technique is DEA.

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

There are numerous studies on port performance with DEA approach, some of them are Wang et al (2002), Tongzon (2001), Valentine and Gray (2001), Martinez-Budria et al. (1999), Roll and Hayuth (1993), Barros and Athanassiou (2004), Turner et al. (2004) and Cullinane et al. (2004, 2005). Recently, Wang and Cullinane (2006) apply DEA on 104 European ports across 29 countries. Rios and Macada (2006) discuss on relative efficiency for Brazilian, Argentinean and Uruguayan container terminals. Besides this, Wanke (2013) highlights two-stage network for Brazilian port where as, Park and De (2004) introduce a four-stage alternative DEA approach on Korean ports.

4.1 Discussion of Input and Output

The research is using 6 container terminals in Peninsular Malaysia as DMU. The data used in this research is from the year 2003 to 2010. The presentation of results are base on general output oriented DEA-CCR and DEA BCC in obtaining efficiency score. The research is used DEA-Solver Pro 7 version for analysis of data for the model. Golany and Roll (1989) highlight that the number of DMUs should be at least twice the number of inputs and outputs for the homogeneity reason. In container terminal industry, the handling equipments for operation are varies from each others. In this case, it is the index approach is used for certain inputs to avoid homogeneity i.e., for quay crane;

Quay Crane's index = Number of quay cranes x average lifting capacity

We use average lifting capacity to indicate average lifting of quay crane at wharf. By using this, we are able to average maximum lifting capacity of quay crane. The lifting capacity of quay cranes are different according to it series i.e., Table 1 depicts Westport Malaysia container terminal informs its quay crane specification and Table 2 represents acronym for input and output.

Table 1. Capacity of Quay Crane

Type	Capacity (Tones)	LASR (Above Deck)	Out Reach (Rows on Vessel)
1-Mitsubishi	35	27M(3)	36M(11-12)
1-Hitachi	30	33M(5)	42M(14-15)
9-Impsa	40	34M(6)	48M(16-17)
2-Noel	41	32M(5)	45M(15-16)
3-Mitsui	41	38M(7)	52M(18-19)
4-Mitsui	41	38M(7)	59M(21-22)
14-Mitsui Twin-lift	50 Single 2x30 Twin	40M(8)	62M(22-23)

(source: Westport Malaysia Container Terminal, 2011)

Table 2. Input and Output

Input(s)	Output(s)
X1: Total Termianl Area in M^2 (TTA) X2: Maximum draft in meter (MD) X3: Berth length in meter (BL) X4: Quay crane index (QC) X5: Yard stacking index (YS) X6: Vehicles (V) X7: Number of gate lanes (GL)	Y1: Throughput (TEU: '000) (T)

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

Table 3 depicts descriptive statistics analysis which represent maximum, minimum, average and standard deviation of inputs and output. The maximum and minimum of TTA are 1800 and 27.28 m^2 respectively. The average and standard deviation for TTA are 723.876 and 535.758 m^2 respectively. Maximun and minimum quay crane index are 1980 and 120 respectively with the average and standard deviation at 724.73 and 508.79. as for output, the maximum and minimum T (million) Teus at 5988.066 and108.108 respectively with the average and standard deviation at 2189.48 and 1776.94.

Table 3: Descriptive Statistics on input/output data

	TTA	MD	BL	QC	YS	V	GL	T
Max	1800	16	4320	1980	120000	589	10	5988.066
Min	27.28	12	400	120	245	26	2	108.108
Average	723.876	13.89583	1840.563	724.7271	27325.6	263.8125	5.354167	2189.483
SD	535.758	1.357688	1135.576	508.7973	32551.84	183.4033	3.017239	1776.944

The descriptive statistics shows the varies in result as the container terminals in Peninsular Malaysia are different in size, equipment and throughput. In addition, correlation between variables is shown in Table 4. Ideally, there is no weak correlation, the lowest at medium correlate (0.607) yet significant. The highest correlations are 0.946 and 0.944 between BL and T, also YS and T. It means all variables are accepted as there are no strong correlations among variables with positive correlation. Table 5 (Apendix) depicts raw data for analysis. The data is used to tabulate the result accordingly.

Table 4: Correlation between Variables

	TTA	MD	BL	QC	YS	V	GL	T
TTA	1	0.610807	0.927261	0.922548	0.818402	0.927538	0.639761	0.912837
MD		1	0.759764	0.641729	0.714635	0.630432	0.761687	0.802556
BL			1	0.909656	0.892678	0.870324	0.833505	0.946187
QC				1	0.878165	0.930087	0.627028	0.924811
YS					1	0.876204	0.690956	0.944483
V						1	0.607006	0.92316
GL							1	0.741228
T								1

4.2.1 Description of Slack

When a unit DMU is most efficient, the Performance Targets for inefficient can be set to ensure DMU reach 100% relative efficiency in comparison with DMU_i. DMU can be set as benchmark, Input Target for DMU_i is describe as follow

Input Target = Actual Input * Efficiency

However, for inefficient DMU, input target will be less than actual input. Hence the difference between actual input and input target is called input slack (Ramanathan, 2003; Mishra, 2012)

Input Slack = Actual Input – Input Target.

In percentage;

$$\text{Input Target} = \frac{\text{Input Slack}}{\text{Actual Input}} \text{ x } 100$$

Whereas,

$$\text{Output Target} = \frac{\text{Actual Output}}{\text{Efficiency}}$$

Therefore,

$$\text{Output Slack=Output Target-Actual Output}$$

In Percentage,

$$\text{Output Target} = \frac{\text{Output Slack}}{\text{Actual Output}} \text{ x } 100$$

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

5. RESULT AND DISCUSSION

Table 6 and 7 represent ranking score for efficient and inefficient DMUs. There are 19 DMU that represent efficient = 1, the other 29 DMUs are inefficient for DEA-CCR. The most inefficient DMU is FK03, in which represent inefficient of 0.607. In general, the bottom 3 of inefficient DMUs are FK04 (0.689) and FK05 (0.668). Rank 20 (FK10), 21(CP08) and EPP07 (0.976) are represent closely efficient for DMUs. The efficient DMUs are i.e., EPP10, AW03, CP10 etc. On the other hand, efficient DMUs for DEA-BCC are 25 and 15 are inefficient i.e., EPP10(1) and FK03(0.6). The inefficient DMUs means that between inputs and output, the utilisation of resources are not as maximum as possible, where there are improvement can be done by container terminal operators in achieving an efficient container terminal. Kasypi and Shah (2012) develop IDEF0 model for lean supply chain to expedite the terminal process flow. The lean supply chain process by using IDEF0 are able to evaluate and execute operational process. The IDEF0 model also used by NATO and Pentagon.

Table 6: DEA-CCR Ranking Score (Output-oriented)

Rank	DMU	Score	Rank	DMU	Score	Rank	DMU	Score	Rank	DMU	Score	Rank	DMU	Score
1	EPP10	1	1	DJ07	1	21	CP08	0.99385	31	EPP09	0.898842	41	FK09	0.795833
1	AW03	1	1	EPP04	1	22	EPP07	0.976441	32	EPP06	0.896025	42	FK06	0.781594
1	CP10	1	1	CP07	1	23	DJ04	0.966026	33	BN09	0.894793	43	FK07	0.772151
1	CP03	1	1	AW07	1	24	BN08	0.947908	34	EPP08	0.88348	44	FK08	0.76889
1	BN10	1	1	DJ06	1	25	BN05	0.943977	35	EPP05	0.877414	45	AW04	0.724195
1	AW10	1	1	CP05	1	26	DJ10	0.937419	36	EPP03	0.845708	46	FK04	0.689216
1	CP09	1	1	DJ05	1	27	BN07	0.931017	37	AW05	0.830416	47	FK05	0.668564
1	DJ08	1	1	CP06	1	28	AW06	0.910046	38	BN04	0.823939	48	FK03	0.607029
1	AW08	1	1	BN06	1	29	DJ09	0.903815	39	BN03	0.800931			
1	CP04	1	20	FK10	0.995605	30	DJ03	0.899813	40	AW09	0.800066			

Table 7: DEA-BCC Ranking Score (Output-oriented)

Rank	DMU	Score	Rank	DMU	Score	Rank	DMU	Score	Rank	DMU	Score	Rank	DMU	Score
1	FK10	1	1	CP08	1	1	BN06	1	31	BN07	0.931017	41	EPP03	0.89133
1	AW03	1	1	EPP04	1	1	CP06	1	32	FK09	0.930826	42	BN03	0.886113
1	EPP10	1	1	FK04	1	1	DJ06	1	33	AW06	0.930272	43	EPP08	0.88348
1	CP03	1	1	AW08	1	1	AW07	1	34	EPP09	0.930069	44	FK03	0.880743
1	CP10	1	1	FK07	1	1	FK06	1	35	EPP06	0.91764	45	AW05	0.831796
1	BN10	1	1	CP05	1	26	FK05	0.970024	36	DJ09	0.903815	46	BN04	0.823939
1	AW10	1	1	DJ05	1	27	DJ04	0.966136	37	DJ03	0.899916	47	AW09	0.800066
1	CP09	1	1	EPP07	1	28	BN08	0.947908	38	BN09	0.894793	48	AW04	0.725481
1	DJ08	1	1	DJ07	1	29	BN05	0.943977	39	FK08	0.89429			
1	CP04	1	1	CP07	1	30	DJ10	0.937419	40	EPP05	0.894209			

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

Table 8 and 9 represent efficiency and projection score inputs and output for DEA-CCR and DEA-BCC. The analysis for DEA-CCR efficiency i.e., AW03 (efficient) in which utilisation of all inputs and output are = 1. It shows that utilisation between inputs and output significantly = 1. The projection score is also efficient when technical efficient =1. It means, all resources allocated for that time are at maximum with the output that produces by container terminal. However, when technical efficient score is inefficient < 1, the projection score is greater than 1, when some of the inputs are not utilised (BN03-1.24).

On the other hand, Table 9 depicts technical efficiency and projection score DEA-BCC. The technical efficiency efficient for AW03(1). However, BN03 (0.80) inefficient for technical efficient and projection score is better than DEA-CCR at 1.12. The reason is DEA-BCC only requires technical efficient in determining the efficiency level rather than DEA-CCR in which, require both scale and technical efficiency to be efficient.

Table 8: Efficiency and projection score of inputs and output of each DMU (Output-oriented DEA, CRS)

No.	DMU	Score	Rank	1/Score	No.	DMU	Score	Rank	1/Score
1	AW03	1	1	1	26	BN07	0.931017	27	1.074094
2	BN03	0.800931	39	1.248547	27	CP07	1	1	1
3	CP03	1	1	1	28	DJ07	1	1	1
4	DJ03	0.899813	30	1.111341	29	EPP07	0.976441	22	1.024128
5	EPP03	0.845708	36	1.182442	30	FK07	0.772151	43	1.295083
6	FK03	0.607029	48	1.647369	31	AW08	1	1	1
7	AW04	0.724195	45	1.380844	32	BN08	0.947908	24	1.054955
8	BN04	0.823939	38	1.213683	33	CP08	0.99385	21	1.006188
9	CP04	1	1	1	34	DJ08	1	1	1
10	DJ04	0.966026	23	1.035169	35	EPP08	0.88348	34	1.131888
11	EPP04	1	1	1	36	FK08	0.76889	44	1.300577
12	FK04	0.689216	46	1.450925	37	AW09	0.800066	40	1.249896
13	AW05	0.830416	37	1.204216	38	BN09	0.894793	33	1.117577
14	BN05	0.943977	25	1.059348	39	CP09	1	1	1
15	CP05	1	1	1	40	DJ09	0.903815	29	1.106422
16	DJ05	1	1	1	41	EPP09	0.898842	31	1.112542
17	EPP05	0.877414	35	1.139713	42	FK09	0.795833	41	1.256545
18	FK05	0.668564	47	1.495744	43	AW10	1	1	1
19	AW06	0.910046	28	1.098845	44	BN10	1	1	1
20	BN06	1	1	1	45	CP10	1	1	1
21	CP06	1	1	1	46	DJ10	0.937419	26	1.066759
22	DJ06	1	1	1	47	EPP10	1	1	1
23	EPP06	0.896025	32	1.11604	48	FK10	0.995605	20	1.004414
24	FK06	0.781594	42	1.279437					
25	AW07	1	1	1					

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

Table 9: Efficiency and projection score of inputs and output of each DMU (Output-oriented DEA, VRS)

No.	DMU	Score	Rank	1/Score	No.	DMU	Score	Rank	1/Score
1	AW03	1	1	1	26	BN07	0.931017	31	1.074094
2	BN03	0.886113	42	1.128524	27	CP07	1	1	1
3	CP03	1	1	1	28	DJ07	1	1	1
4	DJ03	0.899916	37	1.111215	29	EPP07	1	1	1
5	EPP03	0.89133	41	1.12192	30	FK07	1	1	1
6	FK03	0.880743	44	1.135406	31	AW08	1	1	1
7	AW04	0.725481	48	1.378396	32	BN08	0.947908	28	1.054955
8	BN04	0.823939	46	1.213683	33	CP08	1	1	1
9	CP04	1	1	1	34	DJ08	1	1	1
10	DJ04	0.966136	27	1.035051	35	EPP08	0.88348	43	1.131888
11	EPP04	1	1	1	36	FK08	0.89429	39	1.118205
12	FK04	1	1	1	37	AW09	0.800066	47	1.249896
13	AW05	0.831796	45	1.202218	38	BN09	0.894793	38	1.117577
14	BN05	0.943977	29	1.059348	39	CP09	1	1	1
15	CP05	1	1	1	40	DJ09	0.903815	36	1.106422
16	DJ05	1	1	1	41	EPP09	0.930069	34	1.075189
17	EPP05	0.894209	40	1.118306	42	FK09	0.930826	32	1.074315
18	FK05	0.970024	26	1.030902	43	AW10	1	1	1
19	AW06	0.930272	33	1.074955	44	BN10	1	1	1
20	BN06	1	1	1	45	CP10	1	1	1
21	CP06	1	1	1	46	DJ10	0.937419	30	1.066759
22	DJ06	1	1	1	47	EPP10	1	1	1
23	EPP06	0.91764	35	1.089752	48	FK10	1	1	1
24	FK06	1	1	1					
25	AW07	1	1	1					

In Table 10 represents efficiency return to scale for DEA-BCC, where 6 efficient DMUs are increase return to scale and projected are 14 DMUs. The constant return to scale efficient DMUs are 19 and projected is 9 DMUs. There is no decreasing in return to scale for all DMUs. The summary efficiency return to scale represent that there are 19 constant DMUs in compare with previous year i.e., CP03, CP04 and CP05 (efficient = 1) and there are 9 constant projected DMUs i.e., BN07 and BN08 (0.931 and 0.947) respectively. There are 6 DMUs increase return to scale i.e., FK03 (0.8807) and FK04 (1), FK05 (0.970) and FK06 (1). Furthermore, another 14 increase in projected return to scale DMUs i.e., EPP05 (0.894) and EPP06 (0.917), FK08 (0.894) and FK09 (0.930).

Table 10: Technical Efficiency Return to Scale DEA-BCC Score (Output-oriented Rating)

No.	DMU	Score	RTS	RTS of Projected DMU	No.	DMU	Score	RTS	RTS of Projected DMU
1	AW03	1	Constant		26	BN07	0.931017		Constant
2	BN03	0.886113		Increasing	27	CP07	1	Constant	
3	CP03	1	Constant		28	DJ07	1	Constant	
4	DJ03	0.899916		Increasing	29	EPP07	1	Increasing	
5	EPP03	0.89133		Increasing	30	FK07	1	Increasing	
6	FK03	0.880743		Increasing	31	AW08	1	Constant	

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

7	AW04	0.725481		Increasing	32	BN08	0.947908		Constant
8	BN04	0.823939		Constant	33	CP08	1	Increasing	
9	CP04	1	Constant		34	DJ08	1	Constant	
10	DJ04	0.966136		Increasing	35	EPP08	0.88348		Constant
11	EPP04	1	Constant		36	FK08	0.89429		Increasing
12	FK04	1	Increasing		37	AW09	0.800066		Constant
13	AW05	0.831796		Increasing	38	BN09	0.894793		Constant
14	BN05	0.943977		Constant	39	CP09	1	Constant	
15	CP05	1	Constant		40	DJ09	0.903815		Constant
16	DJ05	1	Constant		41	EPP09	0.930069		Increasing
17	EPP05	0.894209		Increasing	42	FK09	0.930826		Increasing
18	FK05	0.970024		Increasing	43	AW10	1	Constant	
19	AW06	0.930272		Increasing	44	BN10	1	Constant	
20	BN06	1	Constant		45	CP10	1	Constant	
21	CP06	1	Constant		46	DJ10	0.937419		Constant
22	DJ06	1	Constant		47	EPP10	1	Constant	
23	EPP06	0.91764		Increasing	48	FK10	1	Increasing	
24	FK06	1	Increasing						
25	AW07	1	Constant						

6. CONCLUSION

This paper analysed technical efficiency of container terminal in Peninsular Malaysia by using DEA. The analysis of technical efficiency for this research covers DEA-CCR and DEA-BCC. There are differences analysis between DEA-CCR and DEA-BCC, where DEA-BCC is only focus on technical efficiency. However, DEA-CCR covers both scale and technical efficiency. This paper acknowleged technical efficiency study on container terminal in Peninsular Malaysia as a gateway to explore the rapid development of its container terminal industry.

This paper synthesise the growth of six (6) container terminals in Peninsular Malaysia as and evidence of development of Malaysia economic activities. The output-oriented ranking for DEA-CCR versus DEA-BCC represent 19 and 25 efficient DMUs and the rest are inefficient DMUs. The additive model without convexity constraints will characterise DMUs as efficient. Therefore, the characterise DEA-CCR for its characteristic, and then CCR's DMU is efficient. It is also similar to DEA-BCC, however because the constraint in DEA-CCR, CCR-efficiency does not exceed BCC-efficiency. Therefore, inefficient result between DEA-CCR and DEA-BCC are different when the most inefficient DMU for DEA-BCC is relatively higher then DEA-CCR. This information could establish the progress of the container terminal development in the future as the latest generation of container vessels are already available in the market. This could help terminal operators plan for terminal expansion in future to cater the market. Even though efficiency does not reflects level of physical infrastructure, the numerical result responds to the future terminal development.

On the efficiency case, the size of container terminal does not reflect significant efficiency towards throughput obtained. The research reflects that container terminal operators must allocate efficiently between all the inputs to ensure utilisation of resources are obtained. However, the progressive action from terminal operators could sustain the terminal development growth.

REFERENCES

Ali, A.I., and Seiford, L.M., (1993) "the mathematical programming approach to efficiency analysis" in The Measurement of Productive Efficiency: Technique and Applications, Fried *et al*. Editors, Oxford University Press, NY

Banker, R.D., Charnes, A. and Cooper,W.W.,(1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science.*, 30, 1078–1092.

Banker, R.D., Conrad, R.F. and Strauss, R. P. (1986) A compara-

tive application of DataEnvelopment Analysis and Translog methods: An illustrative study of hospital production, *Management Science*, Vol. 32, No. 1, 30-44.

Barros, C.P. and Athanassiou, M. (2004) Efficiency in European seaports with DEA: Evidence from Greece and Portugal, *Maritime Economics and Logistics*, Vol. 6, 122-140

Bish, E. K. (2003). A Multiple-Crane Constrained Scheduling Problem in a Container Terminal. *Journal of Operational Research*. 144 (1): 83-107

Carrese, S. and Tatarelli, L., (2011).Optimising the Stacking of the Intermodal Transport Units in an Inland Terminal: An Heuristic Procedure. Procedia *Social and Behavioral Science* 20. pp. 994-1003.

Charnes, A., W.W. Cooper and E. Rhodes, (1978). "Measuring the Efficiency of Decision Making Units" *European Journal of Operational Research* 2(6), pp. 429–444.

Charnes, A., W.W. Cooper, A.Y. Lewin and L.M. Seiford, 1994a. *Data Envelopment Analysis: Theory, Methodology and Application.* Norwell: Kluwer Academic Publishers.

Charnes, A., W.W. Cooper and L.M., (1994b). "Extension to DEA Models" In A. Charnes, W.W. Cooper, A. Y. Lewin, & L. M. Seiford (Eds.). *Data Envelopment Analysis: Theory, Methodology and Applications.* Norwell: Kluwer Academic Publishers.

Coto-Millan, P., Banos-Pino, J. and Rodriguez-Alvarez, A. (2000) Economic Efficiency in Spanish Ports: Some Empirical Evidence, *Maritime Policy and Management*, Vol. 27, 169-174.

Cullinane, K. and Song, D.W. (2003) A Stochastic Frontier Model of The Productive Efficiency of Korean Container Terminals, *Applied Economics*, Vol. 35, 251-267.

Cullinane, K., Ji, P. and Wang, T.F. (2005) The Relationship Between Privatization and DEA Estimates of Efficiency in The Container Port Industry, *Journal of Economics and Business*,Vol. 57, 433-462.

Cullinane, K., Song, D.W. and Gray, R. (2002) A Stochastic Frontier Model of The Efficiency of Major Container Terminals in Asia: Assessing The Influence Of Administrative And Ownership Structures, Transportation Research Part A: *Policy and Practice*, Vol. 36, 743-762.

Cullinane, K., Song, D.W., Ji, P. and Wang, T.F. (2004) An Application of DEA Windows Analysis to Container Port Production Efficiency, *Review of Network Economics*, Vol. 3, 186-208.

Coronado, D., Acosta, M., Mar Cerban. M., and Pilar Lopez, M (Eds) (2006). *Economic Impact of the Container Traffic at the Port Algeciras Bay*. Berlin: Springer.

De Neufville, R. and Tsunokawa, K. (1981) Productivity and Returns to Scale Of Container Ports, *Maritime Policy and Management*, Vol. 8, No. 2, 121-129.

De, P. and Ghosh, B. (2002) Productivity, Efficiency and Technological Change in Indian Ports, *International Journal of Maritime Economics*, Vol. 4, 348-368.

Dowd, T.J. and Leschine, T.M. (1990) Container Terminal Productivity: A Perspective, *Maritime Policy and Management*, Vol. 17, 108-109.

Economic Planning Unit. (2001) Eight Malaysia Plan 2001-2005. Prime Minister's Office, Putrajaya, Malaysia.

Economic Planning Unit. (2006) Ninth Malaysia Plan 2006-2010. Prime Minister's Office, Putrajaya, Malaysia.

Estache, A., Gonzalez, M. and Trujillo, L. (2001) Technical Efficiency Gains From Port Reform: The Potential for Yardstick Competition in Mexico. *Policy Research Working Paper* 2637, The World Bank, Washington, D.C.

Farrell, M. J., 1957, The Measurement of Productive Efficiency, *Journal of Royal Statistical Society A*, 120, 253-281.

Far Eastern Freight Conference. (2005) THCs – Asian Ports. Retrieved 11 January 2007 from the World Wide Web: http://www.fefclondon.com/THCs.

Golany, B and Roll, Y. (1989) An Application Procedure for DEA. *International Journal of Management Science*. Vol.17, No.3, pp 237-250.

Hanrahan, R.P (1995) The IDEF Process Modelling Methodology. Software Technology Support Centre.

Hariharan, K.V. (2002). *Container and Multimodal Transport Management*. Mumbai: SPD Pvt.Ltd.

Hayuth, Y. (1987). *Intermodality: Concept and Practice*. London: Lloyd's of London Press Ltd.

Hayuth, Y. (1994). The Overweight Container Problem and International Intermodal Transportation. *Transportation Journal*. 34 (2): 1-9.

Kasypi, M and Shah, M.Z (2012) Agile Supply Chain for Container Terminal. *International Journal of Sustainable Development*. 04: 05: 69-82.

Kasypi, M., Shah, M.Z., and Muhammad, I. (2013) A Productivity Study of Medium Container Terminal, *The International Journal of Supply Chain Management*, Vol. X, No.1, pp 26-43.

Levinson, M. (2006). *How Shipping Container Made the World Smaller and the World Economy Bigger*. New Jersey. Princeton University Press

Levinson, M and Zhu, S. (2011) The Hierarchy of Roads, the Localityof Traffic and Governance. Transport Policy, 19, pp. 147-154.

Liu, Z. (1995) The Comparative Performance of Public and Private Enterprises, *Journal of Transport Economics and Policy*, Vol. 29, 263-274.

Lovell, C.A.K (1993) "Production Frontier and Production Efficiency in The Measurement of Production Efficency": Technique and Appllications Fried at al. Editors, Oxford Univeristy press, NY.

Mali, P. (1978) Improving Total Productivity: MBO Strategies for Business, Government, and Not-for-Profit Organisation. John Wiley& Son Inc.

Mak, J.N. and Tai, B. (2001) Port Development Within The Framework Of Malaysia's Transport Policy: Some Considerations, *Maritime Policy and Management*, Vol. 28, No. 2, 199-206.

Martinez-Budria, E., Diaz-Armas, R., Navarro-Ibanez, M. and Ravelo-Mesa, T. (1999) A Study of The Efficiency of Spanish Port Authorities Using Data Envelopment Analysis, *International Journal of Transport Economics*, Vol. 26, 237-253.

Mishra, R.K. (2012) Measuring Supply Chain Efficiency: A DEA Approach. *Journal of Operation and Supply Chain Management*.5(1), pp. 45-68.

Northport (Malaysia) Berhad. (2006) Company profile. Retrieved 8 January 2007 from the World Wide Web: http://www.northport.com.my/corporate_profile.asp.

Notteboom, T., Coeck, C. and van den Broeck, J. (2000) Measuring and Explaining the Relative Efficiency of Container Terminals By Means of Bayesian Stochastic Frontier Models, *International Journal of Maritime Economics*, Vol. 2, 83-106.

Paixao, A. C., and Marlow, P. B. (2003). Fourth Generation Ports – A Question of Agility. *Journal of Physical Distribution & Logistic Management*. 33 (4): 355-376.

Park, R.K. and De, P. (2004) An Alternative Approach to Efficiency Measurement of Seaports, *Maritime Economics and Logistics*, Vol. 6, 53-69.

Port of Tanjung Pelepas. (2007) About us: Introduction. Retrieved 8 January 2007 from the World Wide Web: http://www.ptp.com.my/about.asp?id=100001&root=100000

PWD (2009) http://www.jkr.gov.my/ accessed July, 2009

Rios, L.R., and Maçada, A.C.G. (2006) Analysing the Relative Efficiency of Container Terminals of Mercosur using DEA, *Maritime Economics and Logistics*, volume 8, issue 4, pp. 331 – 346.

Rodrigue, J.P (2010) Transportation and Globalization In R. Robertson and J.A. Scholte (eds) Encyclopedia of Globalization, London: Routledge. Forthcoming

Roll, Y. and Hayuth Y. (1993) Port Performance Comparison Applying Data Envelopment Analysis (DEA), *Maritime Policy and Management*, Vol. 20, 153-161.

Ramanathan, R (2003) An Introduction to Data Envelopment Analysis: A Tool for Performance Measurement. New Delhi, Sage Publications

Song, D.W. (2003) Port Co-Opetition in Concept and Practice, *Maritime Policy and Management*, Vol. 30, No. 1, 29-44.

Statistical Unit. (2006) Total container throughput by ports, Malaysia, 1996-2005. Ministry of Transport, Malaysia. Retrieved 8 January 2007 from the World Wide Web: http://www.mot.gov.my/BM/stat/maritim.htm

Slack, B. (2001). Intermodal Transportation, in Ann M. Brewer, Ken Button and David Hensher (eds), *Handbook of Logistic and Supply Chain Management*, New York: Elsevier, pp.141-154.

Sumanth, D. J.(1984). *Productivity Engineering and Management*. New York: McGraw-Hill

Talley, W. K. (2000). Ocean Container Shipping: Impact of a Technological Improvement. *Journal of Economics Issues.* 34 (4): 933-948

Tongzon, J. (2001) Efficiency Measurement of Selected Australian and Other International Ports Using Data Envelopment Analysis, *Transportation Research Part A: Policy and Practice*, Vol. 35, 113-128.

Tongzon, J. and Heng, W. (2005) Port Privatization, Efficiency and Competitiveness: Some Empirical Evidence From Container Ports (Terminals), *Transportation Research Part A: Policy and Practice*, Vol. 39, 405-424.

Transpacific Stabilization Agreement. (2007) Current charges: TSA surcharges charges. Retrieved 11 January 2007 from the World WideWeb:http://www.tsacarriers.org/current.html

Turner, H., Windle, R. and Dresner, M. (2004) North American Container Port Productivity: 1984-1997, *Transportation Research Part E: Logistics and Transportation Review*,Vol. 40, 339-356.

UNCTAD (1993). United Nations Publlication. http://www.unctad.org/en/docs/1993en.pdf. Accessed 8 January 2007

UNCTAD (2001). Implementation Multimodal Transport Rules (Advance Copy). http://unctad.org/en/Docs/posdtetlbd2.en.pdf Accessed, June 2012.

Valentine, V.F. and Gray, R. (2001) The Measurement of Port Efficiency Using Data Envelopment Analysis. Proceedings of the 9th World Conference on Transport Research, Seoul, South Korea, 22-27 July 2001.

Wang, T.F. and Cullinane, K. (2006) The Efficiency of European Container Terminals and Implications For Supply Chain Management, *Maritime Economics and Logistics*, Vol. 8,82-99.

Wang, T.F., Cullinane, K. and Song, D.W. (2005) Container Port Production and Economic Efficiency. Palgrave Macmillan, Basingstoke.

Wang, T.F., Song, D.W. and Cullinane, K. (2002) The Applicability of Data Envelopment Analysis to Efficiency Measurement Of Container Ports. Conference Proceedings of the IAME 2002, Panama.

Wanke, P.F. (2013) Physical Infrastructure and Shipment Consolidation Efficiency Drivers in Brazilian ports: A Two-stage Network-DEA approach, *Transport Policy*, volume 29, issue , pp. 145 – 153.

World Bank. (2005) Road Transport Service Efficiency Study: India. Energy&Infrastructure Operations Division South Asia Regional Office.

Woxenius, J. (1998) Development of Small-Scale Intermodal Freight Transportation in a System Context. Unpublished PhD Thesis. Chalmers University of Technology, Goeteborg Sweden.

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

NOTES

APPENDIX-A

Table 5. Inputs and Output Target for Data Analysis

DMU	(I)TTA	(I)MD	(I)BL	(I)QC	(I)YS	(I)V	(I)GL	(O)T
AW	410	15	2000	360	28551.3	140	8	2300770
BN	846	14	2379	916.8	33135	307	10	2540465
CP	1200	15	2160	1375.2	23405.76	414	3	3168702
DJ	144.56	14	760	200	1437.216	92	3	750466
EPP	578	12	931	308.8	1547.75	225	3	688171
FK	50	14	400	120	300	26	2	108108
AW	890.31	15	2600	800	45081	381	8	2556006
BN	916	15	2713	916.8	32973.2	289	10	2687587
CP	1200	15	2520	1375.2	25572.96	414	4	3668161
DJ	144.56	14	760	200	1437.216	92	3	805689
EPP	578	12	931	308.8	1170.25	225	3	772024
FK	50	12	400	120	300	26	2	122745
AW	890.31	15	2600	800	44130	381	8	2911270
BN	916	15	2892	916.8	28800	227	10	2632257
CP	1200	15	2520	1375.2	42504	414	6	3985464
DJ	144.56	14	760	200	1452	92	3	842303
EPP	578	12	931	960	2378.25	381	3	795289
FK	50	12	400	120	300	26	2	119067
AW	890.31	15	2600	984	58840	445	8	3665201
BN	916	15	2892	916.8	27360	216	10	2681094
CP	1800	15	2880	1080	45584	523	6	4431013
DJ	144.56	14	760	240	1914	92	3	880611
EPP	578	12	931	560	2755.2	207	3	849730
FK	27.28	12	400	135	300	26	2	125920
AW	1133.12	15	2600	1066	58840	445	8	4312717
BN	916	15	2679	1031.4	26999.1	282	10	2805997
CP	1800	15	3600	1215	62400	551	7	5072298
DJ	250	14	760	240	1650	92	3	927284
EPP	578	12	931	560	2755.2	207	3	925991
FK	27.28	12	400	180	350	26	2	127600
AW	1133.12	15	2600	1394	87671.6	584	8	4966969
BN	916	15	2679	747.5	34902.33	270	10	3006610
CP	1800	15	3600	1485	92000	589	7	5154404
DJ	250	14	760	270.2	1848	100	3	934767
EPP	828	12	1700	640	3530.1	249	3	917631
FK	27.28	12	600	180	350	26	2	127061
AW	1133.12	16	3200	1436.5	93259.1	584	8	4453152
BN	934	15	2679	747.5	36486.45	270	10	2856627

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

CP	1800	15	4320	1980	99200	522	7	5538477
DJ	250	14	760	270.2	1848	100	3	844856
EPP	828	12	1500	630	3782.25	249	3	958476
FK	27.28	12	600	180	420	26	2	132252
AW	1133.12	16	3200	1436.5	93259.1	584	8	5565979
BN	934	15	2679	747.5	32972.94	296	10	3304317
CP	1800	15	4320	1980	120000	575	9	5988066
DJ	250	14	760	270.2	1848	100	3	876268
EPP	828	12	1700	630	3782.5	249	3	1067173
FK	27.28	12	600	180	245	26	2	142080

APPENDIX-B

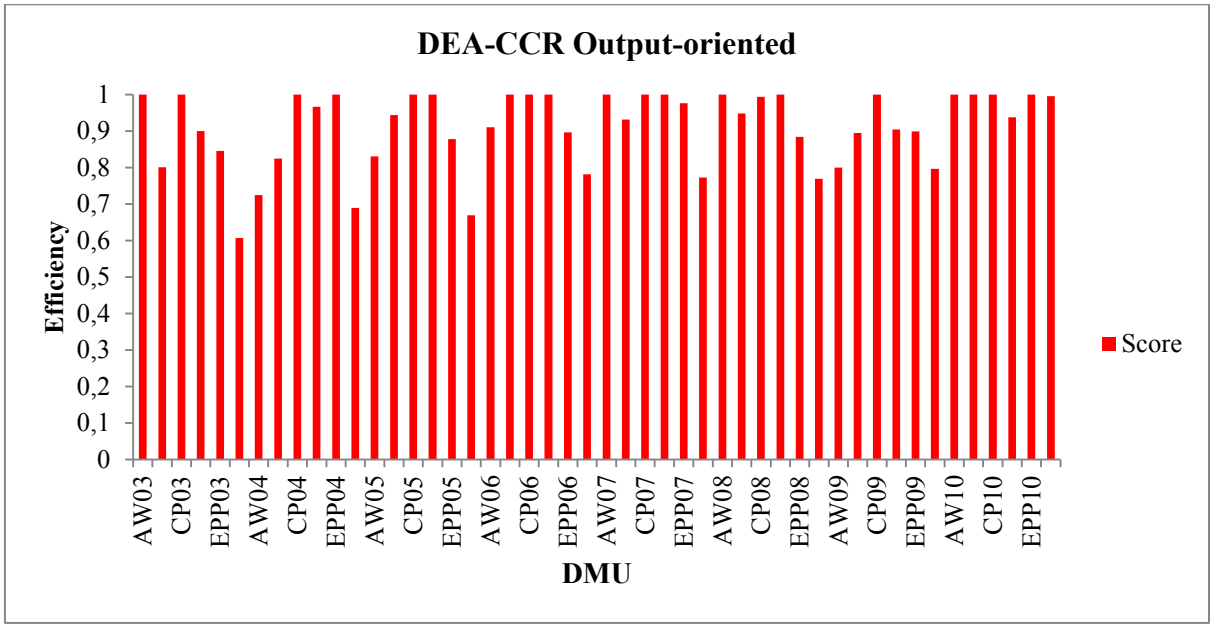


Figure 1-0: Container Terminal Yearly Efficiency(Output-oriented Efficiency Rating)

ISSN: 1984-3046 • Journal of Operations and Supply Chain Management Volume 6 Number 2 pp 1 – 19

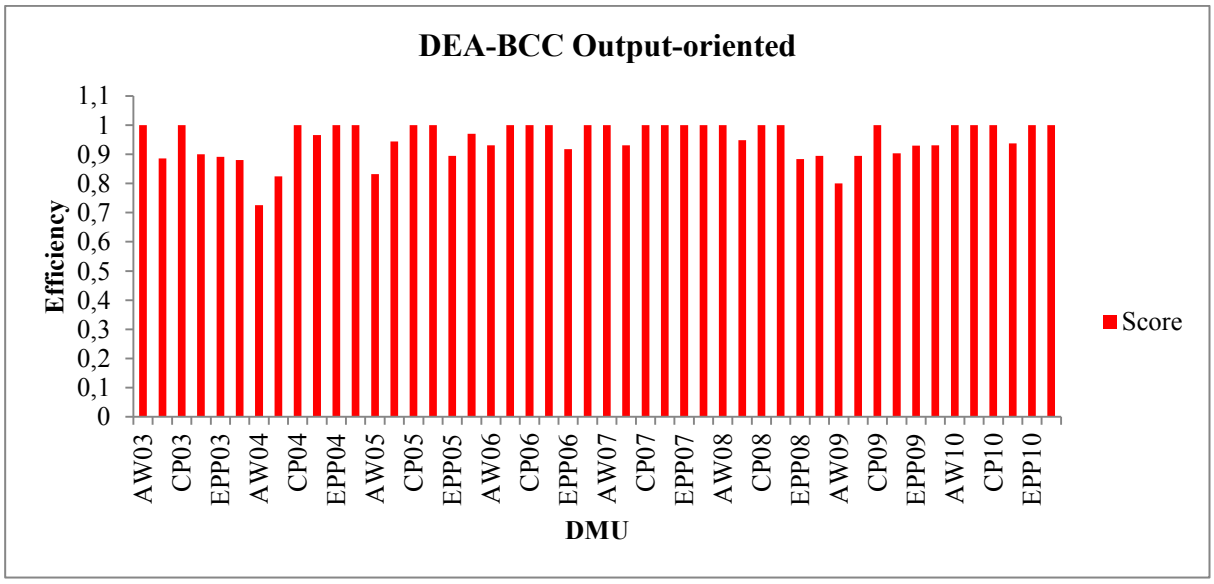


Figure 2-0: Container Terminal Yearly Efficiency(Output-oriented Efficiency Rating)

Mokhtar Kasypi is a lecturer in Department of Maritime Management at Universiti Malaysia Terengganu. Dr. Kasypi worked in operations, logistics and planning for bonded warehouse, logistics and container terminal. He holds Chartered Institute of Transport (UK), and Chartered Member Institute of Logistics and Transport (CMILT). He earned his Msc and Ph.D in transportation planning at Universiti Teknologi Malaysia. Dr. Kasypi has articles published in the *Journal of Supply Chain Management, Business and Sustainable*. Dr. Kasypi plays an active role as Council Member and Secretary for Chartered Institute of Logistics and Transport (Malaysia) and East Coast Section.