Analyzing Private Terminal Efficiency in AEC Using Data Envelopment Analysis (DEA)

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Abstract

Container Terminal is very important in the maritime business including its efficiency of private terminal to be a part of port competition between different countries. However, the purpose of this study is to significantly measure terminal efficiency and inefficiency for improving the performance of the terminal and suggest how to make the terminal more efficient. Therefore, to achieve this objective, 20 private container terminals in AEC countries were select where input and output variables of berth length, number of berths, area, number of gantries crane and quay crane including container throughput were inserted. This research was carried out using DEA (Data Envelopment Analysis) CCR model and BCC model by using DEAP software to analyze the data. The result shows that 7 private container terminals were efficient and 13 were inefficient. In conclusion, there is need to improve the efficiency of the terminals by increasing their input variables and appropriately utilizing the terminal to run efficiently

Keywords: Data envelopment analysis, Private container terminal, terminal efficiency measurement.

I. INTRODUCTION

More than 80 % of international trade use maritime transport to transport goods from the original country to their destination. Including port operation and port facility be a part of efficiency in port terminals (Lin & Lih, 2005).This aspect makes container terminals to be a very important part of maritime transport. Since the terminal is one of the infrastructures used in loading and unloading of ships it supports import and export of goods by maritime transport that connect to the other modes of transport all around the world. Therefore, it is the only best way to successfully transport the large number of goods directly to many countries of the world with the lowest transport cost (Carvalho, 2007)

However, public terminals are described as been controlled by government and hence suffer on policy, lack of cooperation and slow running of operations. On the other hand, private terminals have an opportunity to manage high level of performance on operation and investment of facility and equipment because they are self-sponsored. Private terminals also help the government to enhance competitive and productive international trade and   maritime transport of the nations. That makes a private terminal are main to support the government policy. However, if the private terminal of each nation has an efficient will drive the international trade and port operation higher efficient. This is one of the reasons to evaluate the private container terminal efficiency. On the other have most of the research mostly using DEA evaluated container terminal which mostly considered in the public sector. It one of research gapto evaluate private container terminals (Demirel, Cullinane, & Haralambides, 2012)

AEC (ASEAN Economic Community) is one of the communities to integrate with 10 countries in South East Asia i.e., Myanmar, Thailand, Lao, Cambodia, Malaysia, Vietnam, Indonesia, Singapore, Brunei, and Philippines. The purpose for AEC is to enhance economy, international trade, and investment. The main objective of AEC cooperation is to decrease the custom clearance period and fees and to increase the effectivity and productivity of operating each transport mode including maritime transport (Association of Southeast Asian Nations, 2017). On the other hand, AEC is the third largest economic community and top seventh of the world via container throughput (Kutin, Nguyen, & Vallee, 2017).

DEA is one of the decision unit and efficiency comparisons to estimate the comparative efficiency in many states such as in an area of maritime, economics, transport and etc. to evaluate the efficiency performance which shows the result in scale. As well as it can estimate efficiency or inefficiency including DEA running data to show scale for improving the performance (Abraham Charnes, William W. Cooper, Arie Y. Lewin, & Lawrence M. Seiford, 2013)

Moreover, the determinant of terminal efficiency coming from performance of port to utilize facility and infrastructure such as the number of berths, area of the terminal, length of the terminal, numbers of port equipment (quay crane, yard crane, gantries crane) for comparing with the outcome performance in container throughput. Using DEA to analyze the performance and indicate the efficiency and inefficiency of the terminal for improvement. Thereafter, the efficiency of the terminal can indicate from the results after running the DEA model. If the score of CRS or VRS equals 1 is means that terminals have an efficiency to able to utilize the facility efficiently. In contrast, the results of the efficiency score less than 1 are mean that port inefficiency the score will indicate the terminal need to develop in

terminal to bring forward turn to efficient. (Kutin, Nguyen, & Vallee, 2017) (Pongpanich & Ke, 2016)

In addition, private terminals have their own characteristic in their strange and weakness such as location, congestion and port facility which will impact terminal performance and maritime transport competition. It is therefore very necessary to consider efficiency and inefficiency in order to make improvements on them (Almawsheki, Muhammad, & Ahmed, 2014). The main objectives on this research include: 1. To analyze the efficiency of 20 private container terminals in AEC countries which raking in top 3 container throughput in each nation. 2. Analyze and identify the cause and scale of inefficiency in each terminal for improvement. 3. To design and suggest ways of improving the scale of efficiency in terminals. However, to achieve the purpose of this research, we measure the efficiency of private container terminal using Data Envelopment Analysis (DEA) by taking into account the inserts of multiple input and output. Moreover, consideration in terminal efficiency can demonstrate an improvement of the terminal including developing on Data envelopment analysis methodology to evaluate the efficiency and inefficient of each terminal

This paper contains the research framework shown in figure 1 as literature review regard of DEA in terminal then using the DEA by a specific unit of input data call "Decision management units" (DMU) as 20 private container terminals in AEC and also insert the inputs variables of berth length, number of berths, area, number of gantries crane and quay crane including container throughput is output. After that use DEAP software to analyze the efficiency in terminals including design and suggest a way to improve the efficiency in each terminal. For instance the details of the research as generated. Section 2 consists of the introduction about DEA model and

literature review relating to the measurement of port efficiency. Section 3, gives the details of methodology and equations, including the mode of data collection. After which the research presents the efficiency results in each terminal including the improved scale of efficiency in section 4 and lastly the conclusion in section 5. Introduction is important part of reason why have made the research together with objectives and literature reviews.
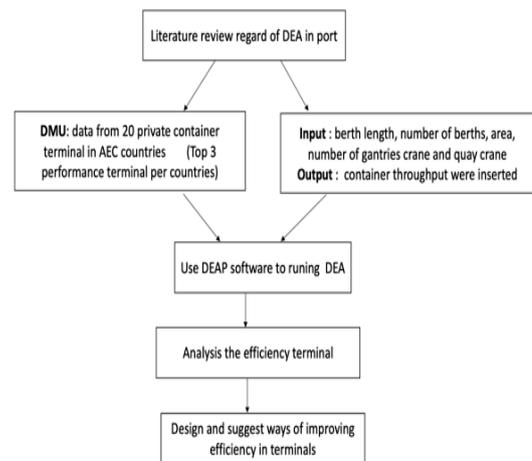

Figure 1 Research framework

II. LITERATURE REVIEW

Terminal efficiency has majorly impacted maritime and inland transportation relating to international trade and the economy in many countries (Bhanot & Singh, 2014). Moreover, the performance of terminals can indicate their strength and weakness in order to evaluate their potential in maritime business. Thus, it is important to measure efficiency of terminals to develop a higher level of performance in the terminals (Lin & Lih, 2005). Several authors have reviewed their literature on the DEA model application to analyze the terminal efficiency as detail below.

A. Evaluation of port efficiency by using DEA

According to this research, Tongzon measured efficiency of 4 main ports and 12 other ports based on the high performance with container throughput. He inserted 6 inputs of the number of cranes, number of container berths, number of tugs, terminal area and the number of laborers working in these terminals. It was considered that 2 outputs were cargo throughput (TEU) and ship working rate which represents the data (1996- latest data available) by using the DEA-CCR model. After analyzing the data, it was found that 4 ports were inefficient. The cause of inefficiency was believed to come from port characteristics such as size and function (Tongzon, 2001)

Zheng and Park studied major ports in Korea and China to analyze their efficiency and the scale used for changing port to be more efficient by using DEAP 2.1 software program. They inserted input data by using the factor of berth length, yard area, number of quay cranes, number of yard cranes and use the container throughput on output factors. The results showed that the efficiency terminal score in Korea (CCR 0.815, BCC 0.886) and China (CCR 0.817, BCC 0.887) were similar. This results contradicts previous studies that suggest that the ports in China were more efficient than ports in Korea (Zheng & PARK, 2016).

In this research, focus was on five ports of a river in Serbia from 2001 to 2008. The purpose of the research was to evaluate efficiency of ports and increase the service performance of ports. The input factors in this port included: productive activities, warehouse area, quay length, number of cranes and port throughput by using DEA window analysis. The results found that the Port of Belgrade and Novi Sad were less efficient because of poor management in operation. In contrast, port of Pančevo and port Smederevo were more efficient. Due to this, the author of this research gave suggestions to increase

port performance in that ports should find more customers to rise the number of cargo being handled in the ports and rent more equipment to increase the capacity instead of investment (PJEVČEVIĆ, RADONJIĆ, HRLE, & ČOLIĆ, 2012)

Lirn and Guo studied and analyzed the efficiency of major ports in the V.I.S.T.A and ASEAN countries by applying DEA-CCR and DEA-BCC model. The input data was terminal area, length of terminals, number of quayside gantries, the number of yard gantries, the number of straddle carriers and output data was the number of container throughput. The results found that only the ports in Singapore and South Africa were more efficient. Hence, they gave a reason for inefficiency of the other ports within the study area as negligence by the operators (Lirn & Guo, 2011).

In this study, comparisons were made of the efficiency of private and public container terminals in areas of Turkey and Wider Eastern Mediterranean region by using DEA-CCR and DEA-BCC model through the TOBIT regression analysis. After their study, they found that container terminals whether private or public were lower in efficiency although private terminals have higher efficiency than public terminals. Lastly, they suggested the development of operations in the terminals to make them more efficient (Demirel, Cullinane, & Haralambides, 2012)

Pongpanich & Ke focused in this study to measure and analyze the efficiency of Thailand container ports from 2006 to 2013 by using DEA – BCC model with windows analysis method. The inputs inserted in this research were: number of ports, length of port, number of cranes, warehouse area and the outputs were quantity products. Results found that Bangkok port was the most efficient compared to Phuket port and Leam Chabang port and the least efficiency was with Songkhla port. Therefore, the suggestion was for the more efficient ports to expand their port size and

maintain the performance in port operations. Lastly, to improve the inefficiency the ports should find more customers and increase their port equipment by renting. (Pongpanich & Ke, 2016)

They studied the efficiency of ports in Northeast Asia by applying DEA-CCR, DEA- BCC and super efficiency models with DEA Excel solver. The results found that 8 container ports had been operated efficiently specifically ports in China and Taiwan were more efficient. Results also found some inefficient ports such as Busan and Gwangyang in Korea. They concluded that the reason for the inefficiency of the other ports came from lack of experience and inadequate technology. Therefore, they suggested that this ports should develop their own operational capacity to a higher level (So, Kim, Cho, & Kim, 2007)

They studied 50 inland ports and seaports in ASEAN countries. The research measures the super efficiency constant return to scale and the efficiency frontier by using DEA - BCC and DEA CCR model with Win4deap2 software and CRS super-efficiency was calculated by R software. The research was generated into 5 categories as; 1. Inland ports and seaports with yard crane 2. Inland ports and seaports with RTG 3. Seaports with yard cranes 4. Seaports with RTG and FTs 5. Inland seaports with yard crane. It measured the efficiency while comparing between seaports and inland ports. The results showed that ASEAN seaports have better performance compared to inland ports (Kutin, Nguyen, & Vallee, 2017) They studied the efficiency of 10 major container ports along with Maritime Silk Road (MSR) including the ports of Shanghai, Hong Kong, Singapore, Kelang, Laem Chabang, Colombo, Dubai, Barcelona, Antwerp, and Hamburg by using DEA model with slack-based measures. It evaluated the environmental performance and operational efficiency by inserting the input data; number of container berth, container

berth length, number of quay crane. The output data were container throughput and CO_2 emission. The results showed that 10 container ports were efficient and 7 were inefficient. Although the ports showed high operational efficiency, there was negligence to the environment due to high CO_2 emissions observed. Lastly, they suggested creating policies to reduce harmful gas emissions to improve the atmospheric conditions of the environment (Dong, Zhu, Wang, & Gaipal, 2019)

This study shows the efficiency of 27 international container ports in 2002 by applying SFA and DEA models with multiple inputs and a single output. The results found that Hong Kong port was more efficient because it had good performance in each model (Lin & Lih, 2005)

B. Data Input and Output

After reviewing many research papers related to ports and terminals efficiency by using DEA model (Fung Ng & LEE, 2007) and the input data to evaluate port performance, port operation, and port efficiency, we found the most of input data was berth length, depth, number of equipment, berth area, number of terminals, number of tugs, number of granty crane, number of quay crane, number of yard equipment, number of straddle carriers, warehouse area and amount of laborers.

All the factors most frequently used in many researches such as the terminal areas, can indicate performance and the efficiency of port operations. It can also determine the amount of cargo transfer through the terminal. The number of berth and number of cranes can measure the productivity of loading and unloading containers (Carvalho, 2007) (PJEVČEVIĆ, RADONJIĆ, HRLE, & ČOLIĆ, 2012). On the other hand, container throughput is the most popular

output factor considered when evaluating the efficiency at terminals in the previous research.

The previous studies focus mostly on public container ports in the region and in each country whereas little focus is given to the private terminals. Hence, for this reason, this research is inspired to focus on private container terminals of 10 countries in AEC and also because the private terminal businesses are run more easily and are part of the port performance in the nation. However, this research uses DEAP software version 2.1 developed by Tim

Coelli (Coelli, 1996) to measure the data and identify the level of efficiency of the container terminals. Lastly, it provides an improved scale of efficiency for the increase and decrease of input and output to make the terminals more efficient. All this reason makes this research different from the previous studies.

In conclusion, all the research involving the use of DEA including input and output data from literature reviews are shown on the table 1 below.

Table 1 Literature of DEA Method on Port Efficiency

Name	Model	Area	Input	Output
(Lin & Lih, 2005)	DEA - CCR DEA – BCC SFA	ASEAN port	- Container gantry cranes - Container quay length - Stevedoring equipment - Container yard	- Container throughput
(Kutin, Nguyen, & Vallee, 2017)	DEA-CCR DEA-BCC CRS super efficiency	ASEAN container port and inland port	- Number of berth - Depth - Container Yard size - Number of yard cranes - Number of RTF and FTs	- Container terminal throughput
(Pongpanich & Ke, 2016)	DEA window analysis	Thailand ports in period 2006 - 2013	- Number of port - Length of port - Number of crane - Warehouse area	- Quantity product
(Dong, Zhu, Wang, & Gaipal, 2019)	DEA-CCR DEA -SBM	Ten major container ports along the Maritime Silk Road (MSR)	- Number of container berth - Container berth length - Number of quay crane	- Thoughtput container - Co2 emission
(Tongzon, 2001)	DEA- CCR	4 Australian and 12 other international container ports	- Number of cranes - Number of container berths - Number of tugs - Terminal area - Number of laborer	- Cargo throughput (TEU) - Ship working rate.
(PJEVČEVIĆ, RADONJIĆ, HRLE, & ČOLIĆ, 2012)	DDA- window analysis	Port in Seria	- Area of warehouses - Quay length - Number of cranes	- Number of port throughput
(Zheng & PARK, 2016)	DEA-CCR DEA-BCC	Container Terminal in Korea and China	- Berth length - Yard Area - Number of quay cranes - Number of Yard cranes	- Container throughput

Table 1 Literature of DEA Method on Port Efficiency (Cont.)

Name	Model	Area	Input	Output
(Lirn & Guo, 2011)	DEA-CCR DEA-BCC	V.I.S.T.A. and the ASEAN countries	- Terminal area - Length of terminals - The number of quayside gantries - The number of yard gantries - The number of straddle carriers	- Container throughput
(Demirel, Cullinane, & Haralambides, 2012)	DEA-CCR DEA-BCC	Container terminals in Turkey and wider Eastern Maditerranenn region	- Quay length - Terminal area - Number of quay cranes - Yard equipment - Draft	- Container throughput
(So, Kim, Cho, & Kim, 2007)	DEA-CCR DEA-BCC	Major Container ports in Northeast Asia	- Berth length - Terminal area - Number of quay cranes - Number of yard equipment	- Container throughput

III. RESEARCH METHODOLOGY

A. Efficiency of Data envelopment analysis

The methodology to evaluate terminal performance and efficiency have various method such as Stochastic Frontier Analysis (SFA), Traditional regression estimation methods, Index number, Corrected original least squares (COLS), data envelopment analysis (DEA) and Original least squares (OLS) (Liu, 2010). However, The most popular method used to measure the efficiency of ports and terminals is called DEA. It is the most frequent method used to measure in academic research (Almawsheki, Muhammad, & Ahmed , 2014).

The concept of Data Envelopment Analysis (DEA) is a mathematical program. Its performance is to evaluate the efficiency of multiple inputs and outputs by giving a number of efficiency units called "Decision management units" (DMU). Thus, this method helps terminals to get results that give the right direction in developing better performance and efficiency (Chávez & Torres, 2014) (Dong, Zhu, Wang, & Gaipal, 2019) (Lee, Chou, & Kuo, 2005)

The mathematical equation of DEA model is expressed as follows: That number of DMU_s where each DMU_j (j=1…, n) by inserting "m" inputs (i=1,…,m). Then utilized to "s" outputs (r=1,…,s) to measure the performance by DMU_j

$$Max\ h_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \text{ for all } j = 1,2, \ldots \ldots, n$$

Subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, j = 1,2, \ldots \ldots, n$$

Where; $v_i \geq 0$, (i=1, 2, 3…, m)

$u_r \geq 0$ (r=1, 2, 3…, s)

The equation is explained as; h_j is relative to the efficiency of DMU, y_{rj} is amount of output and x_{ij} is amount of input. Then "n" is number of DMU including; "s" is number output and "m" the number of input. u_r is the weight given to output r and v_i is the weight given to input i. However, the number of DMUs vary where each DMU_j (j=1,…,n) by inserting

$$Max\ h_0 = \sum_{r=1}^{s} u_r\, y_{r0}$$

$$\text{s.t. } \sum_{i=1}^{m} v_i\, x_{i0} = 1$$

$$\sum_{r=1}^{s} u_r\, y_{rj} - \sum_{i=1}^{m} v_i\, x_{ij} \leq 0\,,$$

$$j = 1,2,\ldots,n$$

$$u_r, v_i \geq \in, \forall\, r, i$$

m input x_{ij} (i=1,…,m), then utilized to output y_{rj} (r=1,…,s) to measure the performance by DMU_j

On the other hand, DEA can evaluate the DMU by expressing the value of *hj;* should range from 0 to 1 to show the efficiency of DMU. When the value of DMU h_j is equal to one then it implies that the DMU is efficient. In contrast, if the value of DMU h_j is close but not equal to 1 then it will be indicated to be less efficient or inefficient

However, DEA model created by Charnes, Cooper and Rhodes (CCR) measured the efficiency by insert, the total input and total output by using a mathematic program. Then, the outcomes were called constant returns to scale (CRS). Afterward, Banker, Charnes and Cooper (1984) developed the BCC model to measure the technical efficiency index with return outcome called "Variable Returns to Scale" (VRS) as shown on figure 2. (Almawsheki, Muhammad, & Ahmed, 2014)
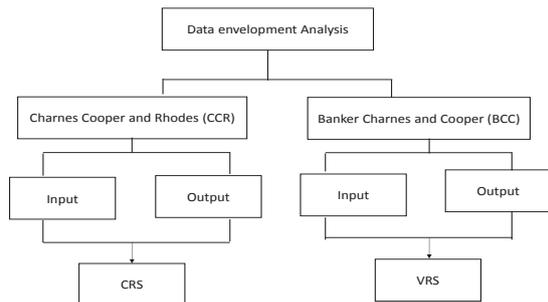

Figure 2 Type of Data Envelopment Analysis

Source: (Sonprom & Somswasdi, 2016)

B DEA- CCR Model

CCR (Charnes Cooper and Rhodes) model provides CRS (Constant Return To Scale). The efficiency of running the CCR model to estimate the values is by inserting the input and output data of each DMU. (Zheng & PARK, 2016)

The meaning of h_0 is relative to the efficiency of DMU. n is a number of DMU. r is the number of input values, i is the number of output values. The x_{ij} amount of the input factor for the DMU and y_{rj} is factor output DMU. As u_r is the weight of output factor and v_i the weight of input factor.

C. DEA- BCC Model

Banker Charnes and Cooper developed BCC model in 1984. It is one of the models used for improving CCR due to the Constant Return to Scale (CRS) of CCR model. This is a weakness on the technical scale efficiency and scale efficiency were results are not different. It makes the DMU of the CCR model inefficient. So, the BCC model returns the efficiency scale which is called as Variables Return to Scale (VRS).

$$Max\ h_0 = \sum_{r=1}^{s} u_r\, y_{r0} + u_0$$

$$\text{s.t. } \sum_{i=1}^{m} v_i\, x_{i0} = 1$$

$$\sum_{r=1}^{s} u_r\, y_{rj} - \sum_{i=1}^{m} v_i\, x_{ij} + u_0 \leq 0$$

$$j = 1,2,\ldots,n$$

$$u_r, xv_i \geq \in, \forall\, r, i$$

A u_0 is a return to scale of DMU.

In the case of u_0 = 0 shows the DMU will be under optimal production and constant return to scale. While, u_0 > 0 the DMU provide decrease

return to scale (drs), In contrast, $u_0 < 0$ DMU provide increase return to scale (irs) (Zheng & PARK, 2016).

Therefore, the value of h_0 in CCR model and BCC model are equal to 1 then it can indicate DMU are efficiency. In contrast, the value of h_0 is less than 1 this DMU are indicated inefficiency. However, the value of h_0 showed the percentage of improving by which DMU should increase or decrease input and output. After that terminals can achieve efficiency. (Tongzon, 2001)

Furthermore, CRS (constant return to scale) & VRS (Variable Returns to Scale) are two measurement tools to measure the scale efficiency. The CRS is generated with the assumption of constant returns to scale. It refers that no assumption that any positive or negative can exit. VRS is considered the existence of multiplier problems by increasing or decreasing returns-to-scale evaluations (Reddy, 2015)In general, research needs to consider both CRS and VRS for calculating in scale efficiency (SE) which the value of SE can indicate the efficient of DMU. in contrast, the results of SE shows inefficient can improving the terminal by increasing or decreasing of input or output for suggesting the inefficient can turn to accomplish efficiency. Lastly, in the case of the results of CRS and VRS are conflicts. Another step that should consider in scale efficiency must be equal to 1can determine that terminal efficiency.

D. Scale efficiency

The scale of efficiency refers to the outputs factors that increase as the same levels of input factors, output factors increase higher than the level of input factor, output factor increases the scale under the level of input factors. CCRTE it is meaning the technical efficiency of CCR model under the assumption of CRS. Meanwhile, BCCTE is a technical efficiency of the BCC model under the assumption of

VRS. The technical efficiency score should be between 0-1. If the score nearly zero it is mean this module far form efficiency. Unlike, if the score nearly to 1 implies that this module nearly efficiency. (Al-Eraqi, Mustafa, & Khader, 2010)

$$\text{Scale efficiency} = \frac{CCRTE}{BCCTE}$$

E. Data collection.

This research considers the private container terminals in AEC countries as Thailand, Myanmar, Vietnam, Singapore, Philippine, Malaysia, Indonesia, and Brunei except (Lao is not available because land lock countries and Cambodia is managed by government) by using DEA method on CCR and BCC model. So, the input indicator (X); using berth length, number of berths, terminal area, number of gantries crane and quay crane. However, the output (Y) will measure container throughput by TEU. All these data are shown in table 2. Hence, the information collected from the official port or terminal website, research paper, general website, and annual report. Lastly, this research using DEAP software by download the program and insert the variable in DEAP excel file design by Tim Coelli (Coelli, 1996) including following on the step and instruction of the program. After that running with DEAP program analyze the efficiency of terminals and it is consider improving percentage to enhance each terminal to meet the efficiency target.

IV. RESULTS AND DISCUSSION

A. The measure efficiency of port

Using the DEA model analysis the efficiency of 20 private container terminals in AEC. The input data considered berth length, number of berths, number of gantries crane, quay crane. Also, output factor be a number of container throughputs per year by using DEAP software. The result of DEA-CCR (CRS), DEA-BCC

(VRS) and scale efficiency apply for measure the efficiency showed in Table 3

Terminals have an efficiency in case of score CRS or VRS be equal 1 which implies that their terminal able to utilize the facility efficiently. In contrast, the efficiency score of CRS and VRS less than 1 is mean that the terminal inefficiency this is indicate that terminal need to improve the facility and some resource to increase their own terminal and bring forward to efficient.

As long as, the score of CRS and VRS are equal to 1 means absolutely efficient. On results shows that it has 7 terminals (35%) were efficiency; terminal as Lai Terminal (CLT) in Vietnam, Manila International Container Terminal, (MICT) and ATI's Container Terminal Division (CTD) in the Philippine shown on the high volume container throughput despite less number of crane and terminal area. In contrast, Pasir Panjang Terminal (PPT) in Singapore, Pelepas Container service APM terminal (APM) and Westport Kelang MIlti terminal (KMT) in Malaysia were efficient because their have a good operate on equipment and terminals area. Then, Jakarta International Container Terminal (JITC) shows efficient because it has a suitable number of equipment but less terminal area.

The results of the VRS score in DEA- BCC evaluate terminal efficiency. It is increasing the number of efficiency terminal top-up from the CRS score in DEA-CCR model (Zheng & PARK, 2016). Therefore, Asia World Port Terminal(AWPT), Myanmar International Terminal Thilawa (MITT), Cat Lai Terminal (CLI), Pasir Panjang Terminal (PPT), Manila International Container Terminal (MICT), Ati's Container Terminal Division (CTD) Davao International Container Terminal (DICT), Pelepas Container Services APM Terminal (APM) Westport Kelang Multi Tmnl (KMT), Jakarta International.

Container Terminal (JICT) and Muara Container Terminal (MCT) were efficient with VRS in DEA BCC model. It brings the average efficient of the total terminal higher than DEA- CCR model. However, the results of terminals were analyze inefficiency as Asia World Port Terminal (AWPT), Myanmar International Terminal Thilawa (MITT), Davao International Container Terminal (DICT), Muara Container Terminal (MCT) despite DEA BCC model are equal 1 but scale efficiency and CRS in DEA – CCR model not equal 1. So, it means that their terminal should be improving. Hence, the inefficient terminals are13 terminals which show "Increasing Return Scale" (IRS). It implies that the terminals should improve the efficiency by increasing to scale.

Table 2 Private Container Terminal Data

Conutries	Port	Private Container Terminal	Berth Length (M)	Number Of Berth	Area (HA)	Gantries Crane	Quay Cran	Container throughput (TEU)
Thailand	THLCH	Hutchison Laem Chabang International Terminal Limited,	3650	5	161.2	86	33	3,500,000
	LCIT	Laem Chabang International Terminal Co., Ltd	900	5	40.5	54	18	883,843
	LCB1	Lcb Container Terminal 1	949	3	35.3	26	10	1,600,000
Myanmar	AWPT	Asia World Port Terminal	852	4	12.31	9	2	370,387
	H.P.T	Htee Tan Port Terminal	438	3	29.13	4	3	400,000
	MITT	Myanmar International Terminal Thilawa	1000	5	75	7	2	380,675
Vietnam	CLI	Cat Lai Terminal	224	8	16.94	20	20	3,500,000
	SITV	Saigon International Terminals Vietnam	730	3	33.7	11	6	1,200,000
	CMIT	Tan Cang - Cai Mep International Terminal	890	3	48	15	5	1,115,000
Singapore	PPT	Pasir Panjang Terminal	13,447	38	424	29	147	18,000,000
Philippine	MICT	Manila International Container Terminal	1,520	6	94.8	8	3	2,750,000
	CTD	Ati's Container Terminal Division	550	5	15	4	9	1,200,000
	DICT	Davao International Container Terminal	423	2	8.8	8	2	404,953
Malaysia	APM	Pelepas Container Services Apm Terminal	14,720	14	180	180	58	12,500,000
	NBCT	North Butterworth Cntr Tmnl	1500	6	59.24	13	8	2,000,000
	KMT	Westport Kelang Multi Tmnl	5,800	20	110	185	67	14,000,000
Indonesia	JICT	Jakarta International Container Terminal	2,350	9	54.74	74	16	5,400,000
	BICT	Belawan International Container Terminal	550	4	15.84	11	6	1,200,000
	NPCT	New Priok Container Terminal One	850	3	32	20	8	1,500,000
Brunei	MCT	Muara Container Terminal	250	1	9.2	2	2	220,000

On the other hand, the scale efficiencies lower than 1 means that private container terminals are inefficient because of it has an excess of inputs compared to outputs which is reflected in the scale efficiency results (Zheng & PARK, 2016).

From table 3 most of ports need to increase the input to improve port more efficiency. Then use DEA with DEAP software to analyze the efficiency of the private terminals. These results can be summarized as ports have efficient performance and those that need to improve in this area.

Table 3 Efficient Results of Private Container Terminal

DMU	Name of port	CRS	VRS	Scale Efficiency	Reason	Remark
DMU1	THLCH	0.8630	0.9480	0.0910	IRS	Inefficient
DMU2	LCIT	0.3000	0.4300	0.6960	IRS	Inefficient
DMU3	LCB1	0.7780	0.9540	0.8160	IRS	Inefficient
DMU4	AWPT	0.4700	1.0000	0.4700	IRS	Inefficient
DMU5	H.P.T	0.3730	0.7420	0.5030	IRS	Inefficient
DMU6	MITT	0.210	1.0000	0.210	IRS	Inefficient
DMU7	CLI	1.0000	1.0000	1.0000		Efficient
DMU8	SITV	0.7650	0.8890	0.856	IRS	Inefficient
DMU9	CMIT	0.6570	0.8120	0.809	IRS	Inefficient
DMU10	PPT	1.0000	1.0000	1.0000		Efficient
DMU11	MICT	1.0000	1.0000	1.0000		Efficient
DMU12	CTD	1.0000	1.0000	1.0000		Efficient
DMU13	DICT	0.5930	1.0000	0.5930	IRS	Inefficient
DMU14	APM	1.0000	1.0000	1.0000		Efficient
DMU15	NBCT	0.7330	0.7750	0.9470	IRS	Inefficient
DMU16	KMT	1.0000	1.0000	1.0000		Efficient
DMU17	JICT	1.0000	1.0000	1.0000		Efficient
DMU18	BICT	0.8350	0.9770	0.8550	IRS	Inefficient
DMU19	NPCT	0.8040	0.9360	0.8590	IRS	Inefficient
DMU20	MCT	0.4860	1.0000	0.4760	IRS	Inefficient
Average	0.74335	0.92315	0.75905			

Analysis for improvement

Table 4 shows analysis result of enhancing an efficiency in each terminal. After using the DEA method to measure the efficiency of 20 private terminals we found that it has 7 private terminals as Cat Lai Terminal in Vietnam, Pasir Panjang Terminal, Myanmar International Terminal Thilawa in Myanmar, Manila International Container Terminal, ATI's Container Terminal Division, Pelepas container service (APM terminal), Westport Kelang Multi, Jakarta International Container Terminal were efficient. However, some of the private terminals measured by DEAP were inefficient and hence need to improve most of the factors ranging from high input to output. Some terminals have many facilities but the outcome is too little than is useful as it has been detailed table 6. This table shows the percentage of increase or decrease of input to make the terminals more efficient.

CRS model found that Myanmar International Terminal Thilawa is the least efficient private terminal in AEC because the improved operations rate in CRS are only as high as 79%. Therefore, this terminal needs to improve its performance to be more efficient by increasing the input; number of berth (input2) 83.38%, terminal areas (Input 3)83.54% and number of Gantries crane (Input 4) 84.14%. This was followed by Laem Chabang International Terminal Co., Ltd (LCIT) in Thailand whereby the improved operations rate in CRS were 70 %. It is therefore needful to increase the input; berth area (Input 3) 84.9 %, Gantries crane (Input 4) 82.19 and number of quay crane 75.07% to make this terminal more efficient. Next, Htee Tan Port terminal and Asia World Port Terminal in Myanmar improved operations CRS score as 62.7 % and 53% respectively. In contrast, efficient private terminals are less improved. It implied that efficient terminals are improved by less increase in input such as Hutchison

Laem Chabang International Terminal Limited in Thailand (THLCH) improved their operation CRS rate by just 13.4% to make this terminal more efficient followed by Belawan International Container Terminal (BICT) and New Priok Container Terminal One (NPCT) in Indonesia by 16.5% and 19.6% respectively.

Furthermore, the analysis of DEA model by VRS shows the same result of CRS model that Laem Chabang International Terminal Co., Ltd (LCIT) needs more increase in the input (56.9%) to improve the terminal's efficiency by adding the input terminal area (Input 3) 69.15%, number of Gantries crane (Input 4) 84.52% and number of quay crane (Input 5) 70.13%. Htee Tan Port terminal in Myanmar (H.P.T) needs to improve their performance by 25.8%. Three private terminals; Myanmar International Terminal Thilawa (MITT), Davoa International Container Terminal (DICT) and Muara Container Terminal (MCT) were well managed. Lastly, results of VRS model showed that Belawan International Container Terminal (BICT) requires less increase by only 2.3% of input to make the terminal more efficient (Huguenin, 2012). In conclusion. Efficient terminals do no need to increase any input and output because the performance performs well. In contrast for inefficiency terminal as there needs to improve by increase and decrease the input to utilize the facility and turn inefficient terminal to be efficient terminal. that efficient terminals are improved by less increase in input such as Hutchison Laem Chabang International Terminal Limited in Thailand (THLCH) improved their operation CRS rate by just 13.4% to make this terminal more efficient followed by Belawan International Container Terminal (BICT) and New Priok Container Terminal One (NPCT) in Indonesia by 16.5% and 19.6% respectively.

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Table 4 Percentage of Improving an Efficient

DMU	Port name	CRS						VRS						
		Improve operation CRS	Berth length	Number of berth	Area	Gantries	Quay crane	Improve operation VRS	Capacity for improvement. adjust optimal size)	Berth length	Number of berth	Area	Gantries	Quay crane
DMU1	THLCH	13.7	13.7	13.7	73.99	43.1	50.27	5.2	9	5.2	5.2	69.4	43.58	48.21
DMU2	LCIT	70	70	70	84.9	82.19	75.07	56.9	30.4	56.9	56.9	69.15	84.52	70.13
DMU3	LCB1	22.2	22.2	22.2	58.3	22.2	22.2	4.6	18.4	4.6	4.6	42.9	21.2	15.11
DMU4	AWPT	53	79.9	83.4	53	53.63	53	-	53	53.58	54.05	23.59	23.58	-
DMU5	H.P.T	62.7	62.7	68.86	66.05	62.7	62.7	25.8	49.7	25.8	54.6	50.7	36.9	25.8
DMU 6	MITT	79	79	83.38	83.54	84.14	79	-	-	-	-	-	-	-
DMU8	SITV	23.5	23.5	23.5	29.79	23.5	23.5	11.1	14.4	11.1	11.1	20	11.1	18.4
DMU9	CMIT	34.3	34.3	34.3	53.13	34.3	34.3	18.8	19.1	18.8	-18.8	50.4	18.8	-18.8
DMU13	DICT	40.7	59.55	63.95	40.7	40.7	40.7	-	-	-	-	-	-	-
DMU15	NBCT	26.7	51.44	27.31	26.7	26.7	26.7	22.5	5.3	45.57	22.5	22.5	22.5	22.5
DMU18	BICT	16.5	45.34	37.45	16.5	16.5	16.5	2.3	14.5	18.19	12.4	2.3	2.3	2.3
DMU19	NPCT	19.6	19.6	19.6	36.60	19.6	19.6	6.4	14.1	6.4	6.4	37.17	6.4	6.4
DMU20	MCT	51.4	62.90	51.4	51.4	51.4	51.4	-	-	-	-	-	-	-

Source : Data collected by the author

Table 5 Summary Analysis Result

DMU	Result analysis			
	CRS	VRS	Scale efficiency	
Efficiency	7 (35%)	11(55%)	CRS	7
Inefficiency	14 (70%)	9 (45%)	DRS	-
Total	20(100%)	20(100%)	IRS	13
AVERAGE	0.74335	0.92315	0.75905	

Source: Data collected by the author

Table 5 shows the summarized results on CCR and BCC model showing that VRS gives higher efficiency results of the terminals compared to the CRS model and also the average of efficiencies were higher than in the CRS, the average efficiency ranged between 0.7 – 0.9. These results imply that all of terminals have relatively high performance.

V. CONCLUSION

The competition in maritime transport all over the world's ports and terminals has become very important especially private container terminals which run port competition in the nation. The purpose of this paper is to use the DEA model (CCR and BCC) to evaluate private container terminals in AEC and focus on the major terminals of each country by using DEAP software program.

The results found that 7 private terminals were more efficient because the CRS and VRS were all equal (=1). On the other hand, 13 private terminals were inefficient (CRS and VRS lower than 1) is imply that imbalance of utilizing facility and number of container throughput lead the result showing inefficient terminal. In contrast, if the terminal operates well it meaning that terminal using the facility well and brings high performance in amount of container throughput in terminal. This paper also provides the score for decreasing and increasing the input and output to enhance the performance to become efficient.

Based on this study, the reason of inefficiency of terminals arose from having excess input factors and underutilized facilities. This contributes to the efficiency performance, hence, the need to reduce the input and increase utilization of the facilities in the terminals. In addition, this research suggests an inefficient terminal should; find more customers to increase the container throughput, use high technology infrastructure such as cranes and improve on terminal operations to increase productivity. Lastly, they should optimize the purpose of terminal equipment and use them more appropriately.

REFERENCES

Abraham Charnes, William W. Cooper, Arie Y. Lewin, & Lawrence M. Seiford. (2013). *Data envelopment analysis: theory, methodology, and application.* London: Kluwer Academic.

Almawsheki, E. S., Muhammad, S. Z., & Ahmed , AI. S. (2014). Efficency analysis of container port: A review. In *The Proceedings of 8th SEATUC SYMPOSIUM.* Malaysia: Universiti Teknologi Malaysia.

Atcharaporn Sonprom., & Jintana Somswasdi. (2016). The efficiency of taxation in provincial revenue of the Northeast by data envelopment analysis (DEA) model. *MBA-KKU Journal, 9*(2), 318-333.

Bhanot, N., & Singh, H. (2014). Benchmarking the performance indicators of Indian Railway container business using data envelopment analysis. *Benchmarking: An International Journal, 21*(1), 101-120.

Carvalho, M. L. (2007). *Performance evaluation of the portuguese seaports evaluation in the european context.* Lisboa: Universidade Técnica de Lisboa.

Navarro-Chávez, C., & Zamora-Torres, A. (2014). Economic efficiency of the international port system: An analysis through data envelopment. *International Business Research, 7*(11), 108-116.

Coelli, T. (1996). *A guide to DEAP version 2.1: A data envelopment analysis (Computer) program.* Armidale: Centre for Efficiency and Productivity Analysis Department of Econometrics University of New England.

Demirel, B., Cullinane, K., & Haralambides, H. (2012). Container terminal efficiency and private sector participation. In *The Blackwell Companion to Maritime Economics* (pp. 571–598). John Wiley & Sons, Ltd.

Dong, G., Zhu, J., Li, J., Wang, H., & Gajpal, Y. (2019). Evaluating the environmental performance and operational efficiency of container ports: An application to the maritime silk road. *International Journal of Environmental Research and Public Health*, *16*(12), 2226.

Fung Ng, A. S., & LEE, C. X. (2007). *Port productivity analysis by using DEA: A case study in Malaysia*. Sydney Australis: The University of Sydney.

Huguenin, J. M. (2012). *Data envelopment analysis (DEA).* Lausanne: IDHEAP.

Kutin, N., Nguyen, T. T., & Vallée, T. (2017). Relative efficiencies of ASEAN container ports based on data envelopment analysis. *The Asian Journal of Shipping and Logistics*, *33*(2), 67–77.

Lee, H. S., Chou, M. T., & Kuo, S. G. (2005). Evaluating prot efficiency in ASIA pacific region with recursive data envelopment analysis. *Journal of the Eastern Asia Society for Transportation Studies, 6*, 544-559.

Lin, L.-C., & Lih, A. (2005). Application of DEA and SFA on the measurement of operating efficiencies for 27 International Container Ports. *Proceedings of the Eastern Asia Society for Transportation Studies, 5,* 592-607.

Lirn, Taih-Cherng, & Guo, J. L. (2011). Analyzing ports efficiency in the ASEAN and the V.I.S.T.A. by data envelopment analysis (DEA) technique. *Journal of the Eastern Asia Society for Transportation Studies, 9*, 2129-2144.

Liu, Q. (2010). *Efficiency analysis of container ports and terminals.* London: Centre for Transport Studies Department of Civil, Environmental and Geomatic Engineering University College London.

Mokhtar, K. (2013). Technical efficiency of container terminal operations: a dea approach. *Journal of Operations and Supply Chain Managemen, 6*(2), 1-19.

PJEVČEVIĆ, D., RADONJIĆ, A., HRLE, Z., & ČOLIĆ, V. (2012). DEA window analysis for measuring port efficiencies in Serbia. *Traffic & Transportation, 24*(1), 63-72.

Poitras, G., Tongzon, J., & Li, H. (1996). *Measuring port efficiency: An application of data envelopment analysis*. Singapore: National University of Singapore.

Pongpanich, R., & Ke, C. P. (2016). The efficiency measurement of container ports in Thailand by using DEA windows analysis approach. *International Journal of Innovate Reserach & Development, 5*(5), 247-253.

Reddy, T. (2015). Comparison and correlation coefficient between CRS and VRS models of OC mines. I*nternational Journal of Ethics in Engineering & Management Education*, *2*(1) 25-28.

Salem Al‑Eraqi, A., Mustafa, A., & Tajudin Khader, A. (2010). An extended DEA windows analysis: Middle East and East African seaports. *Journal of Economic Studies*, *37*(2), 208–218.

So, S., Kim, J., Cho, G., & Kim, D.-K. (2007). Efficiency analysis and ranking of major container ports in Northeast Asia: An application of data envelopment analysis. *International Review of Business Research Papers, 3*(2), 486-503.

Tongzon, J. (2001). Efficiency measurement of selected Australian and other international ports using data envelopment analysis. *Transportation Research Part A: Policy and Practice*, *35*(2), 107–122.

Zheng, X. B., & PARK, N. K. (2016). A study on the efficiency of container terminal in Korea and China. *The Asian Journal of Shipping and Logistics*, *32*(4), 213-220.