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# Port productivity analysis by using DEA: A case study in Malaysia

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**ABSTRACT:**

Recent trends in containerized trade have led to the importance of measuring the performance of container ports. In Malaysia, container ports are mostly situated along the Straits of Malacca, one of the most important shipping lanes in the world. Two of its ports, Port Klang and Port of Tanjung Pelepas (PTP) are ranked amongst the top 20 container ports in the world. In particular, PTP is ranked 16 in 2004, even though it is just a young port which started its operations in October 1999. This paper aims to quantitatively measure the productivity of Malaysian container ports. A cross-sectional performance measurement is carried out, using a DEA approach. To further assess the productivity of the ports over time, a set of panel data is analyzed. In order to compare the productivity of the Malaysian ports with world standards, Port of Singapore is added as a reference.



**KEY WORDS:** ***Productivity, Malaysian ports, Data Envelopment Analysis***



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# 1. INTRODUCTION

Containerized trade has grown significantly in recent years, thanks to globalization trends in economic trade around the world. Container ports, in particular, continue to play an important role in the trade and economic activities of a country. As shipping trends continue to change, it is important for ports to maintain its competitiveness. Recent years have seen a large increase in the size of vessels, influencing shipping liners to follow a hub-and-spoke shipping pattern. This has led to ports within the same region, competing with one another, in order to position themselves as a regional hub port.

In order to evaluate the competitiveness of container ports, performance measurement can be seen as an important tool in evaluating port productivity and efficiency. Performance measurement is used in influencing decision-making strategies at various levels. At the managerial level, performance measurement can give insights into the operational procedures at the port, and labor proficiency levels. This helps to identify areas that need improvement, or training. At the strategic level, the performance measurement of a port can be used to evaluate the port's infrastructure development. This is useful in determining if a particular port is under-utilized or otherwise. In terms of marketing strategies, the productivity and efficiency of a port can influence port tariffs. It also provides insights into setting the direction or scope of the port's activities. Port operators can decide on whether to rely solely on import and export trade activities, or expand to include transshipment services. At the national level, port performance measurement is useful in determining government maritime economic policies. Measurement results can influence the decision of implementing port incentives, such as ancillary services and free trade zones. Results can also provide useful insights into the efficiency of customs clearance procedures, which are equally as important as other port facilities and services.

In Malaysia, container ports play an important role in the country's international trade. In order to evaluate the competitiveness of Malaysian ports, a performance measurement of the ports can provide useful insights. Malaysia is strategically situated within the South East Asia region. The Straits of Malacca, one of the busiest shipping routes in the world, lies between the Peninsular Malaysia, and the island of Sumatra. Historically, Malaysia's main ports were built along the Straits of Malacca, taking advantage of its huge economic potential. This remains until today, with Port Klang, and the Port of Tanjung Pelepas being some of the more well-known Malaysian container ports.

Prior to the 1970s, Malaysia was serviced by two ports, i.e. Penang Port and Port Klang. Up until then, these two ports remained as the main focal points for incoming and outgoing trade. It was during the Second Malaysia Plan (1971 -1975) that two more ports were planned, i.e. Johor Port (completed in 1977) and Kuantan Port (operational in 1984). In the 1980s, two other ports were also completed. Bintulu Port was completed in 1982 and Kemaman Port was completed in 1983. During the years of the First Malaysia Plan to the Fifth Malaysia Plan (1966-1990), the development of ports was inclined towards the expansion of existing ports and the construction of new ports. Little emphasis was given towards improving port performance for facilitating trade growth. Indirectly, this provided an opportunity for the Port of Singapore to develop as a main port for Malaysian global trade activities. However, since the Sixth Malaysia Plan (1991 – 1995), the focus has changed towards improving port facilities and enhancing efficiency in order to cater towards trade growth. This began with several major expansion projects at Penang Port, Port Klang, Johor Port and Bintulu Port. Under the Seventh Malaysia Plan (1996 – 2000), the Port of Tanjung Pelepas (PTP) was planned as a new port located at the southern state of Johor. During the Seventh Malaysia Plan, more than 90 per cent of Malaysia's international trade was conducted through its ports. By the time the Eight Malaysia Plan (2001-2005) was undertaken, various major projects at Westport (Port Klang), Penang Port, Kuantan Port, and PTP were carried out. In the year 2004, Port Klang and PTP were ranked 13$^{th}$ and 16$^{th}$ in the world, in terms of total container throughput. The government continues to focus on various initiatives aimed at enhancing port efficiency. Efforts include improving port performance and facilities, and attracting more ship calls from main line operators, especially at Port Klang and PTP, as outlined in the Ninth Malaysia Plan (2006-2010).

The Malaysian containerized trade volume continues to grow positively. In the year 2005, total container throughput was recorded at 12,029,536 TEUs. This was an increase of 6.1 per cent from the previous year. There are currently 13 main ports in Malaysia. Of these, 8 ports handle containerized cargo, while the rest focus mostly on general or bulk cargo. Table 1 shows the main container ports and their total container throughput in the year 2005.

**Table 1: Total Container Throughput by Ports, Malaysia, 2005**

| Port | Total Container Throughput (TEUs) |
|---|---|
| Port of Tanjung Pelepas | 4,044,811 |
| Westport (Port Klang) | 2,911,270 |
| Northport (Port Klang) | 2,632,257 |
| Johor Port | 836,754 |
| Penang Port | 795,289 |
| Bintulu Port | 147,800 |
| Kuching Port | 143,096 |
| Kuantan Port | 119,067 |

Source: Ministry of Transport Malaysia, 2006

Of these, Northport is considered the pioneer port, being one of the country's oldest ports, and handling approximately 60 per cent of the country's trade. Its 'sister' port, Westport, commenced operations in 1994, and has since grown to an annual terminal capacity of 5,000,000 TEUs. This was achieved through a major expansion program in 2005. Worth mentioning are the achievements of PTP, which has recently been awarded 'Container Terminal of the Year' at the 2006 Lloyd's List Asia Maritime Awards. PTP began operations in 1999, merely recording a throughput of 37, 539 TEUs in 2000. By 2005, PTP grew in leaps and bounds and exceeded the 4 million TEUs mark. New port facilities and various incentives succeeded in attracting some major shipping lines to berth at PTP, including Maersk Sealand in 2000 and Evergreen Marine Corporation in 2002. With more than 95 per cent of its containers designated for transshipment, PTP is proof that the government is no longer limiting the role of Malaysian ports to serving its own hinterland alone.

This paper studies the port performance measurement of 6 container ports in Peninsular Malaysia by using the data envelopment analysis (DEA) approach. A brief literature review on port performance measurement and an introduction on the basic DEA models used in this paper are given in Section 2. Section 3 gives a discussion on data justification. In Section 4, a set of 2005 cross-sectional data of these 6 Malaysian ports is examined by using DEA-CCR and DEA-BCC models. Besides this, a set of panel data from 2000 to 2005 is investigated. In addition, the 2005 cross-sectional data of the Port of Singapore is added to the analysis in order to compare the performance of the Malaysian ports with world standards. Finally, comments and conclusions are given in Section 5.

# 2. METHODOLOGY

A firm's productivity is usually measured by comparing its actual production volume with a production frontier. According to 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. 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. Besides this, Park and De (2004) introduced a four-stage alternative DEA approach on Korean ports.

The first DEA model, DEA-CCR model, was introduced by Charnes *et a*l. (1978). It assumes constant returns to scale so that a change in the input level leads to an equi-proportionate change in the output level. On the other hand, the DEA-BCC model (Banker *et al*., 1984) assumes variable returns to scale where performance is bounded by a piecewise linear frontier. There are other DEA models in the literature, but DEA-CCR and DEA-BCC are the most commonly used models. Suppose we are considering K decision making units (DMU) with M inputs and N outputs. (In our case, a DMU refers to a port.) Let $x_{ik}$ and $y_{jk}$ be the $i^{th}$ input and the $j^{th}$ output of $DMU_k$, respectively. The output oriented DEA-CCR model can be represented by K linear programming problems. Each linear programming problem, $LP_k$, corresponds to a $DMU_k$, where $\theta_k$ reflects the productivity of $DMU_k$ and the productivity score can be calculated by $1/\theta_k$, which is the percentage the $DMU_k$ achieved compared with the virtual output, or say the potential output, that $DMU_k$ should be able to achieve with the same amount of inputs. In the formulation, $\lambda_k$ is the slack output of $DMU_k$.

$$(LP_k) \qquad Max \qquad \theta_k \tag{1}$$

$$Subject\ to:$$

$$\theta_k y_{jk} - \sum_{k=1}^{K} \lambda_k y_{jk} \le 0 \qquad \forall j = 1, 2, \cdots N \tag{2}$$

$$\sum_{k=1}^{K} \lambda_k x_{ik} \ge x_{ik} \qquad \forall i = 1, 2, \cdots M \tag{3}$$

$$\lambda_k \ge 0 \qquad \forall k = 1, 2, \cdots K \tag{4}$$

The linear programming formulation of the DEA-BCC model is similar to $LP_k$ except constraint (5) is added.

$$\sum_{k=1}^{K} \lambda_k = 0 \tag{5}$$

# 3. DATA JUSTIFICATIONS

There are different opinions in the literature on choosing the input indicators. Dowd and Leschine (1990), and Cullinane and Song (2003) suggest that labor information should be included as one of the input indicators. On the other hand, Valentine and Gray (2001) argue that labor information is difficult to obtain and there is a high potential of measurement error. Fortunately, Notteboom *et al.* (2000) show that the number of gantry cranes, and number of dock workers are closely related. Besides this, Tongzon (2001), and Cullinane and Song (2003) suggest using number of berths as one of the input indicators reflecting the berth side productivity, whereas Cullinane *et al.* (2002) and Notteboom *et al.* (2000) define total berth length instead. As argued by Wang *et al*. (2005), berth length is more reasonable because the number of berths can change easily. De Neufville and Tsunokawa (1981), Notteboom *et al.* (2000) and Wang et al (2005) also suggest that information on unloading facilities, such as the number of quay cranes and yard cranes, should also be considered. When considering output indicators, there is no doubt that container throughput is the most appropriate indicator.

In this paper, berth length and number of quay cranes are used as input indicators to reflect berth-side productivity. For yard-side productivity, container yard area and number of rubber-tyred gantry (RTG) cranes plus straddle carriers are chosen. In this study, Penang Port, Johor Port and Kuantan Port are smaller ports in terms of scale, compared with PTP, Westport and Northport. They can only serve small vessels. In order to get the same number of containers as the big ports, they need to serve more vessels. In order to include this factor into the study, the number of ship calls is also used as an output indicator. All the data in this study are obtained from port official websites and interviews with port authorities or port operators.

# 4. EMPIRICAL ANALYSIS

## *4.1 Cross-sectional Data (2005) Analysis*

In this section, cross-sectional data of the year 2005 is investigated. Table 2 shows the summary statistics of the inputs and outputs of the six Malaysian ports. Table 3 shows the results from the DEA-CCR model on cross-sectional data. We can see that both PTP and Johor Port get a 100% productivity score. This means that they performed the best amongst the others, making them the reference ports on the frontier. PTP just started its new phase II of development, their berth length increased 33 per cent by the end of 2004, the number of quay cranes increased 12.5 per cent and the number of yard cranes increased by 17.4 per cent in 2005. One will expect the productivity drops as the inputs increase, but contradictorily, PTP gets the full productivity score. Therefore we can conclude that PTP did a very good job compared with the other ports in 2005. For the two sister ports in Klang, Westport and Northport achieved 95.16 per cent and 82.47 per cent of their potential, respectively. Compare with Northport, Westport and PTP, Penang Port, Johor Port and Kuantan Port are smaller in scale. But still, Johor Port ranks better than Westport and Northport. This means that Johor Port made good use of their inputs to produce outputs, even though it was just a small port. On the other hand, Penang Port is located on the Straits of Malacca, similar (in terms of geographical location) to Westport, Northport and PTP, but it produces only 76.9 per cent of its potential. However, this result can be understood as new container berths were recently added, resulting in a 32.2 per cent increase in total berth length. Besides this, 3 new RTG cranes were added. This new development explains the non-productiveness of the port.

**Table 2: Summary of statistics of six Malaysian ports, 2005**

| | Total Yard Area (Sqm) | Number of Yard Cranes | Total Berth Length (m) | Number of Quay Cranes | Container Throughput (TEUs) | Number of Ship calls |
|---|---|---|---|---|---|---|
| Max | 1,200,000 | 121[1] | 2,880 | 27[2] | 4,044,811 | 5,600 |
| Min | 72000 | 4 | 400 | 3 | 119067 | 473 |
| Mean | 579390 | 52.83333 | 1763.833 | 15.33333 | 1889908 | 3013.167 |
| S.D. | 478094.7 | 42.16357 | 1095.405 | 10.17186 | 1528468 | 1939.429 |

[1] This includes panamax, post-panamax and mobile harbor cranes
[2] This includes rubber tyred gantry cranes and straddle carriers

**Table 3: Results of DEA-CCR model on cross-sectional data, 2005**

| Container Terminal | $\theta$ | Productivity Score |
|---|---|---|
| Northport | 1.21255 | 82.47% |
| Westport | 1.05087 | 95.16% |
| PTP | 1.00000 | 100.00% |
| Penang Port | 1.30040 | 76.90% |
| Johor Port | 1.00000 | 100.00% |
| Kuantan Port | 1.29787 | 77.05% |

Table 4 shows the result from the DEA-BCC model. As one can expect, the productivity of most of the ports increased, compared with the result from the DEC-CCR model. In this case, only Penang Port scored less than 100 per cent of its virtual output.

This result also confirms that the DEA-BCC model performs better when the number of DMUs increases. In this example, we examine only six ports, but five of them are at the frontier. Therefore we can only comment that the port, which is not on the frontier, was not as productive as the other ports. With this result alone, comments on port rankings cannot be justified.

**Table 4: Results of DEA- BCC model on cross-sectional data, 2005**

| Container Terminal | θ | Productivity Score |
|---|---|---|
| Northport | 1.00000 | 100% |
| Westport | 1.00000 | 100% |
| PTP | 1.00000 | 100% |
| Penang Port | 1.21791 | 82.11% |
| Johor Port | 1.00000 | 100% |
| Kuantan Port | 1.00000 | 100% |

### *4.2 Panel Data (2000 – 2005) Analysis*

Cross-sectional data analysis can only provide a snapshot on the performance of the DMUs at a point in time. In order to understand the performance of the six Malaysian ports over time, a set of panel data is studied in two different scenarios. In scenario 1, each port is compared only with its own performance across different years. For each individual port, the set of inputs and outputs for a particular year is treated as an independent DMU. The DEA-CCR model is then applied with these six sets of data representing their performance from year 2000 to year 2005. Table 5 shows the results of all six ports. Since port facilities are expensive equipments, ports are usually upgraded in phases. Once a new phase starts, the set of inputs increases in a considerably big scale. Therefore one can expect a drop in productivity in the first year of the new phase. After that, productivity should climb every year until another new phase comes in. In our case, PTP only operated for two months in 2000, therefore a low productivity is expected. Subsequently, its productivity increased to 100 per cent in 2003 and maintained until 2005, even though another new phase began at the end of 2004. This shows that PTP caught up very well, especially from 2004 to 2005. Westport improved its performance steadily from 59.42 per cent in 2000 to 100 per cent in 2004 and maintained in 2005, even though there was a new phase of development rolled out in 2005. For Penang Port and Johor Port, there is a drop of productivity in 2002 but then productivity increased to 100 per cent in a later year. A new terminal came into operation in Penang Port and there was a small upgrade of equipment in Johor Port in 2005, but still the productivity scores remain 100 per cent in 2005. This shows that the increment in outputs dominates the increment in inputs. The productivity of Northport and Kuantan Port grew from 2000 to 2004 and there was a slight drop in 2005. This drop is not due to an increment in inputs because there was no new equipment added to the ports in 2005, it is caused by the drop of output. In this case, both the throughput and the number of ship calls dropped in 2005 for Northport as well as Kuantan Port.

**Table 5: Results of DEA-CCR model on panel data, 2000 – 2005**

| Container Terminal | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|
| Northport | 76.80% | 87.88% | 95.08% | 100.00% | 100.00% | 98.54% |
| Westport | 59.42% | 76.64% | 87.42% | 96.67% | 100.00% | 100.00% |
| PTP | 23.89% | 78.81% | 78.88% | 100.00% | 100.00% | 100.00% |
| Penang Port | 91.14% | 100.00% | 95.35% | 95.24% | 100.00% | 100.00% |
| Johor Port | 90.90% | 100.00% | 96.03% | 100.00% | 100.00% | 100.00% |
| Kuantan Port | 70.25% | 91.22% | 100.00% | 100.00% | 100.00% | 97.00% |

In scenario 1, ports are compared with its own performance across time. When there is a change of productivity, it is difficult to determine whether the cause is an external factor that affects all the port or it is an internal problem of the port. Therefore, we conduct a window analysis on the set of panel data in order to include the effect of these external factors into consideration. In this study, we take a three years window, which is commonly used for window analysis on ports (Wang *et al.*, 2005). Table 6 shows the result from the window analysis. If ranked in terms of total productivity average, in the right-most column, Johor Port is the best performance port. It is difficult to picture Johor Port as the best performance port, because other bigger and more well-known ports, such as PTP, Westport and Northport receive more attention. We refer back to the workings of the DEA-CCR model in order to investigate this result. The DEA-CCR model compares the actual volume of output 'produced' with the virtual output given by the model. This model is proportional to the size of inputs. Since the size of inputs for Johor Port is not high, compared with the other ports, the virtual output given should not be as big as those big ports. Therefore, although the volume of output is less compared to the bigger ports, Johor Port can still be the best performance port. This is followed by Westport, PTP, Northport and Penang Port. Kuantan Port is the least productive port among the group.

Northport, Penang Port and Kuantan Port consistently under-perform, and never reach a 100 percent productivity level. The trend of improvement in productivity for Northport, PTP and Johor Port is the same as the one in Table 5. For Northport, the productivity improved from 2000 to 2004, but there is a slight drop in 2005. Similar findings were suggested for PTP and Johor Port. For Westport, the result in Table 5 shows that its productivity in 2005 is 100 per cent. However, in scenario 2, it is less than 100 per cent. In scenario 1, the increase in outputs suppress the effect on productivity caused by the increase in inputs such that it remains in the frontier and performs the best, compared with its performance in the other years. When the other five ports come into the picture in scenario 2, the ports remain on the frontier change. There are other ports that perform even better than Westport within the same window. Therefore the productivity score drops in Table 6. The same drop in productivity applies to Penang Port in Table 6. On the other hand, instead of a productivity drop in 2002 and 2003 for Penang Port in Table 5, there is an improvement of productivity in Table 6. Since the frontier is different, there are ports performing worse than Penang Port in 2002 and 2003, compared with the new frontier. Therefore there is an increase in productivity of Penang Port in scenario 2.

**Table 6: Results of DEA-CCR model on panel data with window analysis**

| Container Terminal | Efficiency 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total Average |
|---|---|---|---|---|---|---|---|
| Northport | 63.74% | 74.72% | 89.74% | | | | |
| | | 64.06% | 76.94% | 78.71% | | | |
| | | | 74.05% | 75.83% | 80.06% | | |
| | | | | 75.52% | 79.56% | 77.96% | |
| Yearly Average | 63.74% | 69.39% | 80.25% | 76.69% | 79.81% | 77.96% | 75.91% |
| Westport | 50.77% | 71.69% | 100.00% | | | | |
| | | 62.64% | 88.15% | 98.94% | | | |
| | | | 80.93% | 90.68% | 100.00% | | |
| | | | | 90.37% | 100.00% | 89.96% | |
| Yearly Average | 50.77% | 67.17% | 89.69% | 93.33% | 100.00% | 89.96% | 85.35% |
| PTP | 16.99% | 81.31% | 100.00% | | | | |
| | | 63.83% | 76.90% | 100.00% | | | |
| | | | 76.90% | 100.00% | 100.00% | | |
| | | | | 100.00% | 100.00% | 100.00% | |
| Yearly Average | 16.99% | 72.57% | 84.60% | 100.00% | 100.00% | 100.00% | 84.66% |
| Penang Port | 75.59% | 71.85% | 75.38% | | | | |
| | | 65.42% | 68.64% | 74.50% | | | |
| | | | 63.90% | 69.35% | 77.80% | | |
| | | | | 66.84% | 74.98% | 76.90% | |
| Yearly Average | 75.59% | 68.63% | 69.31% | 70.23% | 76.39% | 76.90% | 71.76% |
| Johor Port | 96.40% | 100.00% | 100.00% | | | | |
| | | 100.00% | 96.03% | 100.00% | | | |
| | | | 96.29% | 100.00% | 100.00% | | |
| | | | | 100.00% | 100.00% | 100.00% | |
| Yearly Average | 96.40% | 100.00% | 97.44% | 100.00% | 100.00% | 100.00% | 99.06% |
| Kuantan Port | 46.96% | 60.98% | 66.85% | | | | |
| | | 60.98% | 66.85% | 66.31% | | | |
| | | | 67.37% | 66.77% | 63.17% | | |
| | | | | 66.77% | 63.17% | 61.09% | |
| Yearly Average | 46.96% | 60.98% | 67.02% | 66.61% | 63.17% | 61.09% | 63.10% |

### *4.3 Analysis with Singapore (2005)*

In this section, we would like to compare the performance of the six ports with the Port of Singapore, the busiest world port in 2005. The result is shown in Table 7. As expected, Singapore becomes one of the reference ports on the frontier because it performs the best. The performance of all the Malaysian ports drop, except for Kuantan Port, but it remains as the least well-performed ports. It is worth noting that Johor Port is also on the frontier even though it is just a small port. For PTP, its productivity score drops to 89.79 per cent of the new virtual standard. Even though it is considered to be productive among the Malaysian ports, it is not productive, when compared with the Port of Singapore.

**Table 7: Results of DEA-CCR model with Port of Singapore**

| Container Terminals | θ | Productivity Score |
|---|---|---|
| Northport | 1.27183 | 78.63% |
| Westport | 1.12712 | 88.72% |
| PTP | 1.11376 | 89.79% |
| Penang Port | 1.46692 | 68.17% |
| Johor Port | 1.00000 | 100.00% |
| Kuantan Port | 1.29787 | 77.05% |
| Singapore | 1.00000 | 100.00% |

Table 8 shows the result from the DEA-BCC model. Again, all the productivity scores increase, compare with the result from DEA-CCR model. Besides Johor Port and Port of Singapore, Northport and Kunatan Port define the reference ports on the new frontier. Because of the new frontier, a new virtual output is generated for each port. This new virtual output must not be higher than the one from the DEA-CCR model. Therefore all the productivity scores increase. It is worth noting that the productivity score of Northport is lower than Westport and PTP in table 7, but it is now higher in table 8. This means that when we consider the scale size of the port, Northport performs better, similar for the case between Westport and PTP. Penang Port is still the least productivity port.

**Table 8: Results of DEA-BCC model with Port of Singapore**

| Container Terminals | θ | Productivity Score |
|---|---|---|
| Northport | 1.00000 | 100.00% |
| Westport | 1.03702 | 96.43% |
| PTP | 1.04366 | 95.82% |
| Penang Port | 1.35179 | 73.98% |
| Johor Port | 1.00000 | 100.00% |
| Kuantan Port | 1.00000 | 100.00% |
| Singapore | 1.00000 | 100.00% |

# 5. CONCLUSIONS

This paper presents a performance measurement analysis of 6 container ports in Malaysia, using a Data Envelopment Analysis approach. From our results, we find that PTP and Johor Port emerge as best performers when compared to the other Malaysian ports. This conforms with PTP’s world ranking in terms of container throughput, as well as the number of awards it has won in recent years (this includes the Lloyd's List Maritime Asia Container Terminal Of The Year Award in 2006, and the Lloyd’s List Best Emerging Container Terminal Award in 2000 and 2001). In terms of geographical location, PTP and Johor Port are located relatively close to one another. Since PTP is the more aggressive port between the two, it is suggested that the port authorities at Johor Port first focus their strategies on conventional cargo services, that being their core service. They should also be encouraged to continue with their achievements in handling containerized cargo.

In this analysis, we find that both Westport and Northport do not perform very well, especially in Northport's case. It is suggested that these two ports strengthen their co-operation efforts, in order to increase their competitive power. As an illustration, we consider the scenario where a container arrives at Westport, but is designated for a warehouse in the free trade zone of Northport. Although the container is only being transferred between these two terminals and not entering the country, separate customs declarations for both ports are required. Lack of an existing dedicated channel for such transfers causes time delay and additional costs to shippers. Simplifying such procedures can increase the connectivity between the two ports, thereby improving overall competitiveness for both ports. This would subsequently attract more customers to call at both ports, thus creating a "win-win" situation. In contrast, similar transfers between the different port terminals at the Port of Singapore do not require such procedures. It is therefore not surprising that although Terminal Handling Charges (THCs) in Port Klang are cheaper than those in Singapore, most shippers tend to favour calling at Singapore, due to the additional 'hidden' costs incurred in Port Klang, as mentioned above.

Our analysis also compares the Malaysian ports with the Port of Singapore. With the availability of current resources, we find that the Malaysian ports have the capacity to cater for more container throughput and ship calls. In this regard, we suggest for the port authorities to focus their direction on strengthening their marketing strategies in order to attract more business. Malaysian ports have an advantage of being situated along the Straits of Malacca, one of the busiest shipping routes in the world. This route connects both India and China, and it is anticipated that traffic along this route will increase in the coming future. Thus, it is suggested that the Malaysian ports equip themselves with the capability to increase, not only container throughput, but also market share in this area.

Based on this study, we suggest that the Malaysian port authorities, with the support of the government, should co-operate and work together in order to promote the country's international trade industry. Currently, different ports in different states are being monitored by the respective port authorities. As such, it is suggested that federal government agencies can play a part in over-seeing the co-operation between the different port authorities, and strengthen their developments inline with national policies. Other efforts such as improving inland transportation, promoting intermodal transportation and improving cross-border transportation (into inland countries) should also be encouraged.

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