

Port Efficiencies in Indonesia: Lesson Learnt from Selected Ports¹

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This Policy Research Paper was prepared for the Indonesia Services Dialogue under the USAID-SEADI project.

Indonesia's ports were reported underperformed. Earlier studies tend to use one output, dwelling time to measure the port performance, such as World Bank (2013).

This policy brief offers another perspective on measuring the port performance using the Data Envelopment Analysis (DEA), which measures how efficient inputs used to get certain output. The advantage of this measure is it allows multiple inputs and multiple outputs in the model.

Indonesia's Ports is Relatively Inefficient

We analyze 4 major ports, 2 Class 1 categories ports and 1 special port using two different models. First, Model 1 uses 2 outputs and 4 inputs. Second, Model 2 uses 1 output and 4 inputs. We compare the selected container terminals in the 7 ports to the ones in Singapore, Malaysia and Thailand.

In the analysis, we use four inputs, main inputs used and available in all ports being compared. First, number of cranes used in each container terminal, which is considered the most fundamental equipment. Second, number of tug boats in each terminal. Third is the total length of berths in each container terminal. The last input would be the terminal area of the container terminal. As for output, there will be two different outputs considered. The first model will use two outputs (throughput and dwelling time). The second model uses only one output (throughput). Table 1 shows the results for Model 1 and Table 2 shows the results for Model 2.

Based on the results of the first model, Out of the 10 observed ports, four ports are evaluated as having been operated at an optimal level. With Singapore presumably being the reference, Tanjung Pelepas, Port 6 and Port 7 have managed to achieve an equal level of efficiency with Singapore with respect to their input.

Although operating below optimal level, Laem Chabang achieved a relatively high efficiency score of 93.5%, meaning that they should be able to achieve a their current level of output with 6.5% less input. Further improvement could be made in the management of Tug Boats and Container Terminal Area to reduce Dwelling Time.

¹ This policy brief is made possible by CSIS-ERIA research on port efficiencies. Substantial financial support for the port field survey is provided by ERIA.

Four other Indonesian ports being assessed ranked 6 to 9 respectively in the efficiency ranking, with a relatively close efficiency score of 69%-74%. While crane operation has been efficient in each of these ports, better management in the inputs could be made to increase output.

Table 1 DEA Efficiency Results² 1
Two Outputs – Throughput and Dwelling Time

DMU	Rank	Theta
Port 1	8	.715135
Port 2	7	.729158
Port 3	6	.739903
Port 4	9	.696168
Port 5	10	.182611
Port 6	1	1
Port 7	1	1
Singapore	1	1
Tanjung Pelepas	1	1
Laem Chabang	5	.935466

DMU	Port 1	Port 2	Port 3	Port 4	Port 5
Port 1	-	-	-	-	-
Port 2	-	-	-	-	-
Port 3	-	-	-	-	-
Port 4	-	-	-	-	-
Port 5	-	-	-	-	-
Port 6	-	-	-	-	-
Port 7	-	-	-	-	-
Singapore	-	-	-	-	-
T. Pelepas	-	-	-	-	-
L. Chabang	-	-	-	-	-

DMU	Port 6	Port 7	Singapore	T. Pelepas	L. Chabang
Port 1	-	-	.0703116	0.120191	-
Port 2	-	.303408	.0406175	-	-
Port 3	-	.0469329	.0192241	-	-
Port 4	.203902	-	.0235931	0.2571	-
Port 5	.107963	-	-	0.006889	-
Port 6	1	-	-	0	-
Port 7	-	1	0	-	-
Singapore	-	-	1	-	-
T. Pelepas	-	-	0	1	-
L. Chabang	-	.220922	.0382253	-	-

² As stated above, the DEA procedure used in this report uses the Constant Returns to Scale. Furthermore, this DEA uses the input oriented specification using the two-stage process.

DMU	Slack					
	Length	Crane	Tugs	Area	TEU	D. Time
Port 1	360.873	-	-	10.0059	15704.1	-
Port 2	28.1387	-	3.82196	-	-	.0903332
Port 3	-	-	1.75923	3.48723	185178	-
Port 4	-	-	4.08396	-	47072.4	-
Port 5	173.16	0.335609	-	-	46674.5	-
Port 6	-	0	0	-	-	-
Port 7	-	-	0	0	-	-
Singapore	-	0	0	0	-	-
T. Pelepas	-	0	-	0	-	-
L. Chabang	-	-	4.96929	7.37599	-	.0556722

Source: Author's calculation

By comparing the efficiency rankings of the first and second model, it can be observed that the results of both models differ only slightly. Port 6, Port 7, Singapore and Tanjung Pelepas still places on top of the efficiency rankings, followed by Laem Chabang in the fifth spot.

**Table 2 DEA Efficiency Results³
One Output - Throughput**

DMU	Rank	Theta
Port 1	7	.710232
Port 2	6	.729158
Port 3	9	.51626
Port 4	8	.664664
Port 5	10	.104043
Port 6	1	1
Port 7	1	1
Singapore	1	1
Tanjung Pelepas	1	1
Laem Chabang	5	.935466

DMU	Port 1	Port 2	Port 3	Port 4	Port 5
Port 1	-	-	-	-	-
Port 2	-	-	-	-	-
Port 3	-	-	-	-	-
Port 4	-	-	-	-	-
Port 5	-	-	-	-	-
Port 6	-	-	-	-	-

³ The DEA procedure used in this report uses the Constant Returns to Scale. Furthermore, this DEA uses the input oriented specification using the two-stage process.

Port 7	-	-	-	-	-
Singapore	-	-	-	-	-
T. Pelepas	-	-	-	-	-
L. Chabang	-	-	-	-	-

DMU	Port 6	Port 7	Singapore	T. Pelepas	L. Chabang
Port 1	-	-	.0698295	.0119367	-
Port 2	-	.303408	.0406175	-	-
Port 3	-	.032747	.0134134	-	-
Port 4	.194675	-	.0225255	.0245465	-
Port 5	.0615118	-	-	.003925	-
Port 6	1	-	-	0	-
Port 7	-	1	0	-	-
Singapore	-	-	1	-	-
T. Pelepas	-	-	0	1	-
L. Chabang	-	.220922	.0382253	-	-

DMU	Slack					
	Length	Crane	Tugs	Area	TEU	D. Time
Port 1	358.399	-	-	9.93728	15704.1	.0149843
Port 2	28.1387	-	3.82196	-	-	-
Port 3	-	-	1.22749	2.43318	185178	-
Port 4	-	-	3.89915	-	47072.4	.0234957
Port 5	98.6584	.191214	-	-	46674.5	-
Port 6	-	0	0	-	-	-
Port 7	-	-	0	0	-	-
Singapore	-	0	0	0	-	-
T. Pelepas	-	0	-	0	-	-
L. Chabang	-	-	4.96929	7.37599	-	-

Source: Author's calculation

What factors contributing to the inefficiencies?

The DEA results show how inputs has been used optimally to deliver the particular outputs, in our research the quantity of containers been loaded and unloaded (throughput) and the length of time to get the goods to the ship or to the gate (dwelling time). The results show that most of Indonesia's major ports are not operating at its optimal level.

Are there any factors that prevent ports operating at optimal level? In some ports other factors are significantly affect the level of inefficiencies. First, the time needed to arrange pre clearance process (documents process). Second, custom clearance process. Third, port congestion and road congestion affects port clearance process when containers is removed from port and loaded into truck and importers settled payments to terminal.

Concluding Remarks

The DEA show that 5 out of 7 Indonesia's ports being assessed are inefficient. Port 7 is located in Free Trade Zone in which import goods rarely require custom clearance so it is expected that it is relatively efficient compared to the benchmark. Port 6, which is not in the Free Trade Zone is the only "normal" port that is relatively efficient compared to the other 5 ports. Some other factors might contribute to the efficiencies (shown in suboptimal output), among others are, pre clearance document processing, custom clearance, port and road congestion.

References

- CSIS (2013), Port Services in Indonesia: An Assessment, Jakarta
- Charnes, A., Cooper, W.W., Rhodes, E. (1978). *Measuring the efficiency of decision making units*. European Journal of Operational Research 429 – 444
- Tongzon, J. (2001). Efficiency measurement of selected Australian and other international ports using data envelopment analysis. Transportation Research Part A 35

Appendix

Data Envelopment Analysis

DEA analysis provides a method to involve multiple inputs as well as multiple outputs to evaluate efficiency. Furthermore, DEA calculation are non-parametric and do not require explicit determination of inputs and outputs as well as rigid weight of the various factors being used.

Basically, the DEA attempts to create a relative efficiency measure based on a single virtual output and a single virtual input. Efficiency is determined by choosing Decision Management Units (DMUs) which are most efficient in transforming the virtual input into the virtual output. Formally, assume that there are n DMUs evaluated, where each DMU consumes varying amounts of m different inputs to produce s different outputs. More specifically, DMU _{j} consumes $X_j = x_{ij}$ amount of inputs while producing $Y_j = y_{rj}$ outputs ($r=1, \dots, s$).

The $s \times n$ matrix of output measures is denoted by Y while the $m \times n$ matrix is symbolized by X . With the assumption that $x_{ij} > 0$ and $y_{rj} > 0$, consider the problem of evaluating the relative efficiency for any one of the n DMUs. In order to do so, a ratio of a weighted sum of outputs to a weighted sum of inputs is

created, subject to the constraint that no DMU can have a relative efficiency score greater than one. Symbolically :

$$\max_{u,v} \frac{\sum_r u_r y_{r0}}{\sum_i v_i x_{i0}} = \frac{u^T Y_0}{v^T X_0}, \quad \text{where } u = (u_1, \dots, u_s)^T, \quad v = (v_1, \dots, v_m)^T$$

subject to

$$\frac{u^T Y_j}{v^T X_j} = \frac{\sum_r u_r y_{rj}}{\sum_i v_i x_{ij}} \leq 1$$

$$\text{for } j = 1, 2, \dots, n; \quad u_r, v_i \geq 0 \quad \text{for } r = 1, 2, \dots, s \quad \text{and } i = 1, 2, \dots, n,$$

Where u_r and v_i assigned to output r and input i as weights, respectively.

The DEA model being used in this research is the CCR model, named after its developers, Charnes, Cooper and Rhodes. The CCR model results in a constant returns to scale, piece wise linear envelopment surface with both input and output orientations for projection path. According to Tongzon (2001), the CCR model is preferable when calculating port efficiency because it requires a relatively smaller number of DMUs compared to other models such as the Additive and BCC models. An analogy to conventional economics would feature a linear production possibilities frontiers with a piecewise convex frontier. The linear frontier would be tangent to the convex frontier only over a segment, being above the convex frontier elsewhere.