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Analysis of seaports efficiency in supporting inter-island transportation

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Abstract

This study analyzes the efficiency of 15 ports in Indonesia that connect the islands; users' perceptions on the needs of sea transport facilities both in ships and terminals; and a network of passenger facility needs based on preference. The research uses the sequential mixed method. The results show that 4 of the 15 port samples have not yet reached efficiency. The main reasons why users choose ships are because ships have complete facilities and are therefore more convenient, allow them to carry more goods, at affordable ticket prices, and users usually travel in groups. Users are most concerned with and want complete facilities, comfort, safety and order, viability and accessibility to reach the ports and board the ships.

Introduction

Indonesia is an archipelago consisting of over 16,056 large and small islands separated by 12 seas and 47 straits. These separate islands require sea transportation facilities. Sea transportation is an important part of economic growth both regionally, nationally and internationally. The port is also an important infrastructure to develop the regional economy especially to equalize development. The results of a study analyzing spillover effects from land-based ports to the mainland indicate that in areas with a distance to the nearest major port of more than 150 km, the manufacturing sector contributed only 5.9-7.1% to Gross Regional Domestic Product (GRDP). An area located 29-67 km from the nearest main port has a relatively low poverty rate of 10.3-12.2%, or 10% lower than other areas located more than 200 km from the nearest main port. Other results indicate that ports on the island of Java and those outside of Java have differences (Yudhistira & Sofiyandi, 2017).

Research conducted in the port of Rotterdam, The Netherlands, also shows that the port has contributed 3.5% of the Dutch economy (Wildenboer, 2015). This economic growth is related to the increasingly smooth distribution of goods, especially exports and imports. The study used the number of containers and tons of cargo as the main indicators to measure how much port development has increased the number of goods distributed Many of the characteristics and performance of ports affect economic growth. There are some key factors determining port performance: location, access from inland, accessibility, company presence at the port, terminal efficiency, port costs, and growth in economic and development activities (Langen, Range, & Langen, 2012).

Other research states that The Marine Transportation System (MTS) is very valuable to the United States because it a) provides a global gateway to the world market for US businesses and consumers; this became an important passageway for military mobilization; b) provides domestic transport networks for goods and passengers; c) creates jobs that support maritime operations (commercial and recreational); d) generates tax/tariff revenue and operating income for federal, state and local governments; e) supports the use of recreation by the public. The data show that this MTS generates $ 750 billion in the United States and handles 95% of all foreign trade (American Association of Port Authorities, 2005).

Passenger ports are also important in the development of marine transportation. A study was conducted at 20 major passenger ports in Europe to identify and classify the various services provided and the private and public benefits generated by the provision of services in all passenger ports (Vaggelas & Pallis, 2010). The study found that 1) operational management status will change to a new model if it is managed commercially; 2)

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increased adoption of market value will encourage private players to be more active in service strategies; 3) the number of professionally managed and profit-oriented ports is growing; 4) specialization services by private operators increase business and industry activities; 5) there is an emerging perspective that ports should be public infrastructure and administered by the government (Vaggelas & Pallis, 2010).

Ports of passengers and goods in Indonesia are public infrastructure managed by the ministry of transportation through Pelindo Limited Company. The data show that empirically, sea transport modes have an important role primarily due to the geographical conditions of the Indonesian archipelago. However, in reality, Indonesia's national shipping competitiveness is still relatively weak. The national fleet share growth is 46.4% for domestic transport and 3.65% for overseas transport. Indonesia's geographical condition of which 75% of its territory is the sea has a real potential of sea transportation of 20 billion dollars, but the Gross Domestic Product (GDP) of the sea transportation sector only reached the US $ 1.95 billion or only about 9.7% of its true potential. In fact, the market size for sea transportation, when compared with other modes, remained very low at 1.0% in 2011, which then increased to 3.5% in 2012 and 6.1% in 2013. These figures are fairly low if compared with Indonesia's market size potential (Ministry of Transportation, 2016).

Surveys of private companies managing sea transportation show that some of the reasons for the low role of sea transport in Indonesia are government regulations and their weak implementation, old and not regularly upgraded fleet, investment difficulties due to perception that sea transportation generates low yields, high ports operation and sunk costs, and the lack of port and terminal facilities (Indonesian Marine Council, 2012). Therefore, the Indonesian government has launched a sea toll road for the next five years. The various structures and infrastructures are aimed at port development and improvement of port facilities and passenger terminal. The move is quite successful as indicated by the increasing market size of sea transportation to 12.25% in 2014. Departing from the background mentioned above, this study aims to (1) analyze the efficiency of 15 ports in Indonesia that connect the islands; (2) analyze users' perceptions of the needs of sea transport facilities both in ships and terminals; (3) build a network of passenger facility needs based on preference.

Research Method

Passenger ports are an important part of transportation, especially for maritime areas. However, due to its small contribution to GDP, this type of port has received little attention in research. Thus the definition of passenger ports becomes unclear and is considered a small part of the port function. Ship passengers possess special characteristics because the journey takes longer and is sometimes full of uncertainty due to natural factors such as high waves (Vaggelas & Pallis, 2010).

Ports are often considered to have a simple function, namely ship service, passenger service, and cargo service. However, services can be sorted in more detail into services for the ship convenience to dock, where the dock's length and depth become the determinant variables; passenger comfort regarding rest, meal and hygiene facilities; and security and safety (American Association of Port Authorities, 2005).

Servqual, or service and quality, is a new term that refers to the improvement of service in various fields particularly, in this context, ports. According to ISO, the definition of quality is complex with the ultimate goal of providing satisfaction for customers by meeting their implicit and explicit needs. The optimization of service usually receives inadequate attention because it will increase operational service cost. Since ports are public infrastructure, facility improvements that require high investment often do not take into account the rapid returns, so the government has a big role and responsibility so that funds spent from the State Revenue and Expenditure Budget can encourage improved service and port efficiency (Pantouvakis, Chlomoudis, & Dimas, 2008).

The method used in this research is a sequential mixed method that combines quantitative and qualitative analysis. Qualitative analysis is used to explain the preferences of passengers and other actors related to the condition of ships and ports. Information about passenger preferences can be obtained not only through passengers but also through other actors, such as ticketing agencies, merchants, and labor suppliers. The three actors are chosen as informants because they are directly or indirectly interact with the passengers so that they are considered to understand the characteristics of the ship passengers. This research uses Data Envelopment Approach and ATLAS.ti.

In general, there are two types of approach for measuring efficiency levels: parametric and nonparametric (Saaty, 2008). The approach of Stochastic Frontier Approach (SFA), Thick Frontier Approach (TFA) and Distribution-Free Approach (DFA) are the parametric approaches, while nonparametric approaches include Data Envelopment Approach (DEA) and Free Disposable Hull (FDH). DEA is a non-parametric linear

programming approach assisted with technical efficiencies software packages, such as Banxia Frontier Analysis (BFA) and Warwick for Data Envelopment Analysis (WDEA) (Charnes, Cooper, Lewin, & Seiford, 1994).

DEA is used to measure the efficiency of an Economic Activity Unit (EAU). There are three benefits derived from efficiency measurement using DEA namely:

a. Serving as a benchmark to obtain the relative efficiency that is useful for facilitating comparison between existing economic units.
b. Measuring the various efficiencies between economic units to identify factors
c. determining the policy implications to increase the efficiency level.

Coelli, Rao, O'Donnell, & Battes (2005) illustrate a simple idea involving firms that use two inputs (x1 and x2) to produce an output (y). The assumption used in the illustration is Constant Return Scale. Using an isoquant curve with a fully efficient firm condition depicted on the SS line in Figure 1. Point P describes the use of a given input by the firm to produce one unit of output. Companies that are not technically inefficient in production are depicted over the QP range which is the sum of the input usage proportionately reduced without reducing the output. This is denoted in percent by calculating the ratio of QP / 0P, which indicates the input that can be reduced. The level of company technical efficiency can be described through the following ratio:

$$TE = 0Q/0P \quad (1)$$

The value of the equation is equal to 1-QP / 0P. The value to be obtained ranges from 0 to 1 and this becomes an indicator of the degree to which the company has achieved technical efficiency (technically efficient). For example, point Q is a technical efficiency point because it lies in the isoquant curve.

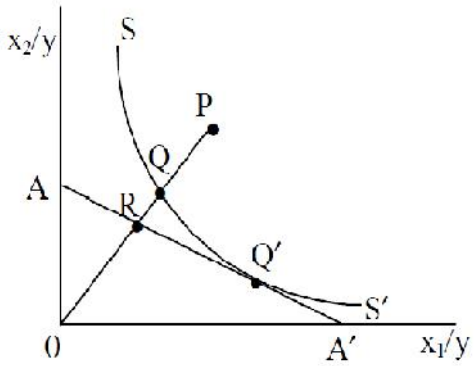

Figure 1. Technical Efficiency and Allocative Efficiency

Results and Discussion

Assessment of performance results between companies or management units can be compared by using some tools, but the most commonly used is Data Envelopment Analysis. DEA is a non-parametric optimization technique using a linear programming tool to measure the relative efficiency of a set of Decision Making Units. In this study, to evaluate the driving performance of each older driver by combining all the 16 hierarchically structured indicators in one index score, a multiple layer DEA based composite indicator model (Babaee, Bagherikahvarin, Sarrazin, Shen, & Hermans, 2015; Drennan & Brecher, 2012).

The first objective of this research is to analyze the efficiency of 15 ports in Indonesia that connect the islands. Port efficiency measurements were made using DEA analysis. The input variables consist of (i1) The dock length (m); (i2) the dock depth (m); (i3) Pelindo Human Resources (org); (i4) terminal building width (m2); (i5) parking area width (m2); and (i6) availability of passenger boarding bridges (PBB). The output variables consist of (o1) maximum ship tonnage (GT / thousand); (o2) the number of ship visits (units); (o3) the number of passengers arriving (org); (o4) the number of passengers departing. Table 1 contains detailed data on ports, inputs, and outputs.

Table 1. Detailed data on ports, inputs, and outputs

		Average until August 2017									
		Output	Output	Output	Output	Input	Input	Input	Input	Input	Input
		Visits/GT/ thousands	Visits/ unit	Arrival/ Persons	Departure/ Persons	Dock/m	Depth/m	Pelindo HR/persons	Building/ m2	Parking/ m2	PBB
1	Tanjung Emas	56.521	13	5.963	5.228	493	9	13	4.450	10.542	0
2	Tanjung Perak	157.691	29	18.261	26.760	1.457	11	25	12.950	9.297	1
3	Tanjung Priok	132.763	27	9.621	10.788	902	11	25	7.266	11.283	0
4	Belawan	51.545	12	4.375	5.548	502	10	17	3.577	8.423	1
5	Makasar	64.580	14	11.739	13.704	871	9	13	3.990	7.276	0
6	Jayapura	45.271	12	6.102	11.505	472	9	10	2.672	5.872	0
7	Fakfak	34.796	10	5.281	5.957	402	9	7	2.170	5.290	0
8	Sampit	30.278	9	3.676	2.514	397	9	7	1.720	4.380	0
9	Kumai	46.711	12	5.538	4.222	481	8	10	2.250	3.975	0
10	Merauke	35.938	10	4.124	3.970	428	9	10	2.465	5.250	0
11	Karimunjawa	6.270	3	312	172	121	3	4	492	2.500	0
12	Kijang, Kepri	34.979	10	5.152	4.827	272	9	10	1.450	2.230	0
13	Lembar	36.224	16	4.744	3.628	291	9	10	1.803	2.445	0
14	Bau Bau	32.278	11	3.281	3.889	210	9	10	1.570	2.350	0
15	Batulicin	29.279	8	2.831	2.916	164	8	7	540	1.210	0

Source: Pelindo Data, 2017

The input and output variables are then analyzed using DEA through the input-oriented model approach, and the results show that 11 ports have reached efficiency: Tanjung Perak, Tanjung Priok, Napier, Jayapura, Fakfak, Kumai, Karimunjawa, Kijang, Kepri, Sheet, Odor Odor, Batulicin. Meanwhile, the following four ports have not achieved efficiency:

Tanjung Emas with an efficiency value of 93.65% and an inefficiency value of 6.35%

Table 2. Inefficiency Value at Port of Tanjung Emas, Semarang

Input	Actual	Target	To Gain	To Gain (%)	Achieved (%)
Dock/m	493	461,7002	-31,2998	-6,35%	**93,65%**
Depth/m	9	8,428605	-0,57140	-6,35%	**93,65%**
Pelindo HR/persons	13	12,17465	-0,82535	-6,35%	**93,65%**
Building/m2	4450	2768,319	-1399,16	-31,44%	**68,56%**
Parking/m2	10542	4799,063	-5073,64	-48,13%	**51,87%**
PBB	0	0	0	0,00%	**100,00%**

Source: raw data processed with DEAMAX, 2017

Belawan with an efficiency value of 76,43% and an inefficiency value of 23,57%

Table 3. Inefficiency Value at Port of Belawan

Input	Actual	Target	To Gain	To Gain	Achieved
Dock/m	502	383,6794	-118,321	-23,57%	**76,43%**
Depth/m	10	7,643017	-2,35698	-23,57%	**76,43%**
Pelindo HR/persons	17	11,08305	-4,00687	-23,57%	**76,43%**
Building/m2	3577	2546,688	-843,093	-23,57%	**76,43%**
Parking/m2	8423	4586,965	-1985,29	-23,57%	**76,43%**
PBB	1	0	1	100,00%	**100,00%**

Sampit with an efficiency value of 96,28% and an inefficiency value of 3,72%

Table 4. Inefficiency Value at Port of Sampit

Input	Actual	Target	To Gain	To Gain	Achieved
Dock/m	397	320,1466	-62,0863	-15,64%	**84,36%**
Depth/m	9	8,066183	-0,57140	-6,35%	**93,65%**
Pelindo HR/persons	7	6,739622	-0,26038	-3,72%	**96,28%**
Building/m2	1720	1656,021	-63,9785	-3,72%	**96,28%**
Parking/m2	4380	4105,515	-162,922	-3,72%	**96,28%**
PBB	0	0	0	0,00%	**100,00%**

Source: raw data processed with DEAMAX, 2017

Merauke with an efficiency value of 81,89% and an inefficiency value of 18,11%.

Table 5. Inefficiency Value at Port Merauke

Input	Actual	Target	To Gain	To Gain	Achieved
Dock/m	428	350,4832	-77,5168	-18,11%	**81,89%**
Depth/m	9	7,369974	-1,81114	-20,12%	**79,88%**
Pelindo HR/persons	10	8,18886	-1,81114	-18,11%	**81,89%**
Building/m2	2465	1968,253	-446,446	-18,11%	**81,89%**
Parking/m2	5250	4299,152	-950,848	-18,11%	**81,89%**
PBB	0	0	0	0	**100,00%**

Source: raw data processed with DEAMAX, 2017

The results of data processing show that the port with the lowest efficiency is one of the big ports, Belawan, with 23% inefficiency value. After further analysis, it was found that inefficiency occurred in all ports due to wastefulness and unused input scale. Ports can serve more output than they do as shown in the tables. Inefficient ports will achieve 100% optimal efficiency when using the following benchmarks:

Table 6. Benchmark efficiency of passenger ports

NO	DMU	Score	Benchmark (Lambda)
1	Tanjung Emas	0,936512	03(0,221108); 05(0,171050); 11(0,115476); 12(0,170477); 13(0,001134); 15(0,320755)
2	Belawan	0,764302	02(0,014865); 03(0,230851); 06(0,131931); 11(0,245213); 15(0,377140)
3	Sampit	0,962803	07(0,657845); 11(0,126217); 13(0,039425); 15(0,176514)
4	Merauke	0,818886	03(0,073687); 05(0,002416); 07(0,374948); 09(0,135254); 11(0,260633); 13(0,074714); 15(0,078349)

Source: raw data processed with DEAMAX, 2017

Table 5.6 shows that inefficient ports will achieve efficiency concerning benchmarked ports, as described below:

1. Tanjung Emas Port will achieve efficiency when referring to the Ports of Tanjung Priok, Makassar, Kijang Kepri, Karimunjawa, Lembar, and Batulicin
2. Belawan Port will achieve efficiency when referring to the Ports of Tanjung Perak, Tanjung Priok, Makasar, Jayapura, Karimunjawa, and Batulicin.
3. Sampit Port will achieve efficiency when referring to the Ports of Fak-fak, Karimunjawa, Lembar, and Batulicin
4. Merauke Port will achieve efficiency when referring to the Ports of Tanjung Priok, Makassar, Fak-fak, Kumai, Karimunjawa, Lembar, and Batulicin

The second objective of this research is to analyze the user perception toward the requirement of sea transport facility both in ship and port terminal. The UNCTAD report shows how to assist developing countries by improving port performance. Its important view is to reduce transportation costs and improve the

quality of port services in an integrated manner to achieve global trade (UNCTAD, 2016). Perception data is obtained through in-depth interviews of informants which include passengers, ticket agents, shop owners and port officers. The coded interview data are grouped into two: the reasons for choosing ships and port facilities. The interview result shows that the characteristics of the ship passengers are having low education, low economic life, from rural/mountainous areas, departing in groups or with family, and are informal workers.

Passengers are users of various means of public transport, including users of land, air and sea transportation. Passengers are a group of people on a journey with the same purpose. Transportation and travel conditions will affect passenger behavior. The main factors are environmental factors covering the social environment, the natural environment, and the economic environment; personal factors include education, social status and age; and group factors that passengers in traveling will interact with other passengers (Li, Jin, & Guo, 2013).

The next step is to connect between the codes with transcripts of interview results so that quantitative results will be obtained from qualitative data. Quantitative is used as a measure of emphasis or how significant the perception of the informants is against the predetermined criteria. The more frequently the criteria are mentioned, the more important the criteria are. The results of code and criteria processing using ATLAS.ti show that the characteristics of ship passengers are those with low education, working in the informal sector and departing in groups. Meanwhile, the reasons for choosing a ship as a mode of transportation are due to the affordable ticket price, the facilities, the possibility to carry large quantities of goods, and the convenience. Passengers will choose the sustainable mode of transportation due to several factors: costs that must be incurred, attitudes and character of passengers, risks or security of transportation and travel modes, as well as terminal and surrounding conditions (Chee & Fernandez, 2013). The respondents' perception of the ports indicates that ports are now more attractive because of their complete facilities, safety, and viability, as shown in the following table:

Table 7. Passenger Preferences on Ship Selection

NO	CODING CRITERIA	VALUE	NO	CODING CRITERIA	VALUE
1	**Reasons for preferring ships**	**26**	2	**Port Facilities**	**27**
	a. Affordable Tickets	**5**		**a. Viability**	**5**
				(i) Clean toilet and public facilities	3
	b. Comfortability	**5**		(ii) Flood safe	2
	(i) Spacious	1			
	(ii) Clean bathroom	1		**b. Facilities and comfortability**	**13**
	(iii) Comfortable passenger cabin	1		(i) Mosque	2
	(iv) Socializing	2		(ii) Free toilet	4
				(iii) seats and space for rests	1
	c. Facilities	**8**		(iv) shops/kiosks	2
	(i) Free meals and drinks	3		(v) spacious hall	1
	(ii) Cafe and entertainment	3		(vi) the clean waiting lounge	3
	(iii) Safety	2			
				c. Accessibility	**4**
	d. Travelling in large groups	**2**		(i) Easy access from outside the port	2
				(ii) Easy access to board the ships	2
	e. Carrying many goods	**6**			
				d. Security and orderliness	**5**

The results indicate that the main reasons why passengers choose ships are because ships have complete facilities, allow them to carry more goods, are more convenient, affordable ticket prices, and because passengers usually travel in groups. Users are most concerned with and want complete facilities, comfort, safety and order, viability and accessibility to reach the ports and board the ships.

The third purpose of this research is to build the network of passenger facility needs based on informant preference. The result is shown in figure 2:

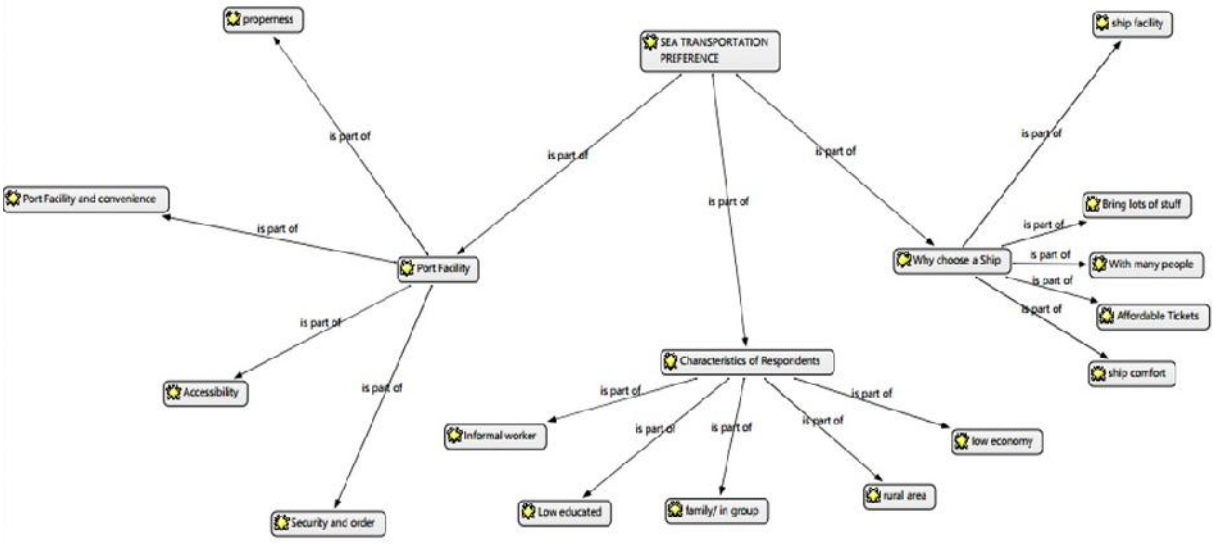

Figure 2 Preference Network of Shipboard Facilities

Conclusion

It can be concluded that 11 (73.33%) ports have reached efficiency, while the other four ports have not reached efficiency, although they are main ports, namely, Belawan, Tanjung Emas, Sampit, and Merauke. Port of Belawan obtains the lowest efficiency value with 76,43%. The four ports have not achieved efficiency due to input wastefulness compared to the output produced.

Based on preference analysis, the main reasons why passengers choose ships is because ships have complete facilities, allow them to carry more goods, are more convenient, affordable ticket prices, and because passengers usually travel in groups. Users are most concerned with and want complete facilities, comfort, safety and order, viability and accessibility to reach the ports and board the ships.

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