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Concentration of Container Throughput in the Hub Ports of Indonesia

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Abstract*—The concept of sea-highway or tol laut has received great attention from the government as reflected in the National Medium-Term Development Plan (RPJMN) 2015–2019. In addition to 25 strategic ports all over the country, five hub ports (Belawan, Tanjung Priok, Tanjung Perak, Makasar, and Bitung) regularly receive large freight vessels, from the west to the east and vice versa. Unloaded cargo at the hub ports is then delivered to feeder ports throughout the country. Container throughput is heavily concentrated in the ports of Java such as the Port of Tanjung Priok in Jakarta and the Port of Tanjung Perak in Surabaya. Although the implementation of sea-highways has not yet been effectively completed, changes in the concentration of port throughput need to be observed; for example, whether there has been a dynamic change in the role of the ports. By using the Gini index, this paper aims to explore the changes in the concentration of domestic loading and unloading of cargo in strategic ports all over the country between2005 and 2015, and the application of the spatial Gini model to analyze the concentration of container throughput in the hub ports.

Keywords*—spatial concentration, Gini index, cargo transportation, sea-highways

I. INTRODUCTION

Seaports in Indonesia are believed to have played a substantial role in managing the supply chain that involves the production and distribution of commodities that can affect the nation's development and stimulate economic growth. Port services are indisputably important for Indonesia because Indonesia is surrounded by the sea that connects big and small islands, helping the country to distribute goods domestically and internationally. The seaports serve as trade gateways that influence the development and growth of the country. However, this great potential is yet to be utilized properly by Indonesia and is lagging compared to other maritime countries in Southeast Asia.

The ports in Indonesia are categorized as below average compared to the rest of the world. Poor infrastructure connectivity in Indonesia has resulted in higher logistic costs, thus presenting logistic costs higher when compared to the ASEAN average. Based on the Logistics Performance Index, Indonesia ranked 63rd out of 160 countries in 2016. Hence, knowledge about seaports is an important factor that affects the distribution of goods, especially for Indonesia.

The Government of Indonesia has provided 17 guidelines in maritime development that essentially intend to make Indonesia a maritime country. These guidelines include maritime and human resources development, defense and security, establishment of a good, transparent national and international marine governance system, maritime infrastructure for equitable connectivity and development improvement, increased production capacity and technology for the national shipping industry, as well as integration of maritime services to support Blue Economy.

The emergence of a new center of economic activity will, directly and indirectly, affect trade flow and will change the trade structure. Although a sea-highway has started, it will take time to see its impact on trade flow. This paper aims to analyze the changes in the concentration of loading and unloading of domestic goods between regions through hub and feeder ports, using the spatial Gini approach. The data are among other obtained from the Directorate General of Transportation on the development of loading and unloading goods between 2000 and 2015.

II. LITERATURE REVIEW

Over the last 50 years, containerization has grown to account currently for roughly 70% of the total value of deep-sea trade and it is a key component of the global economy [1]. Mohamed-Chérif [2] recognized the dynamics of ports and their relations to regional integration through the land-based transport connectivity in Morocco. Numerous studies on the structure of port competition and changes in the concentration of container transportation in ports have been analyzed by Notteboom [3], Notteboom [4], Fowler [5], Hayuth [6], and Wang [7]. Most of the studies on port concentration relies on Hirschman Herfindahl Index or Theil's entropy. Notteboom [3] measured the concentration of ports of Europe between 1980 and 1994 that were characterized by some trends in port evolution, such as concentration and deconcentration of container cargos. Using Gini coefficient and Theil 's entropy of traffic data from major ports in India, De and Chaudury [8] compared the concentration of port traffic over time.

Ideally, changes in the structure of interregional trade can be analyzed using interregional input-output (IRIO) table. However, the limitation of time-series data has been a constraint to capture the emergence of new sectors that have some impact on interregional trade linkages. To overcome this problem, a partial survey that reflects the reality in the field is crucially needed in order to evaluate the results of the maritime policy. Again, the question about changing the concentration of ports in terms of interregional trade flows cannot be fully analyzed.

III. RESEARCH METHODOLOGY

Gini coefficient is a common approach to analyze household or individual income distribution of a country or region. The figure of Gini coefficients ranges from zero to one. Zero Gini index means that income distribution is in perfect equality where all households or individuals have the same income. Otherwise, the Gini index of one shows a perfect inequality where one household or individual has the only income in the distribution. Fowler, for example, relies on analysis of Gini coefficients to measure the concentration of the entire North American container-port. However, from a spatial perspective, the Gini coefficient cannot reveal where the source of income disparity happened. It cannot accommodate the impact of inter-household transfer from one region to others on the Gini index. In another word, the Gini coefficient is a single index that is locationally invariant [9]. It tells us that there is inequality in a region, but not where it is happening within the region [10-13]. The whole map measure of Gini index is insensitive to the absolute and relative position of the value observations across the map [9].

Standard Gini coefficient can be measured as:

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2n^2\bar{x}}$$

Where, xi and xj is loading (unloading) in port i and j respectively, n is number of ports, x is average loading (unloading). The above standard Gini is measured without counting for interregional connection from port i and j.

Spatial Gini is a development of Gini coefficient that accommodates interregional household transfer. This method is relevant for the case of interregional trade flows between ports. Using spatial Gini, the change in cargo loading and unloading of a pair of ports of origin and destination can be identified. Change in interregional trade flow will affect the overall concentration index.

According to Rey and Smith [9], in the case of interregional port loading and unloading, the standard Gini model is decomposed in the form:

$$\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j| = \sum_{i=1}^{n}\sum_{j=1}^{n}(w_{i,j}|x_i - x_j| + (1 - w_{i,j})|x_i - x_j|)$$

then,

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{i,j}|x_i - x_j|}{2n^2\bar{x}} + \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}(1 - w_{i,j})|x_i - x_j|}{2n^2\bar{x}}$$

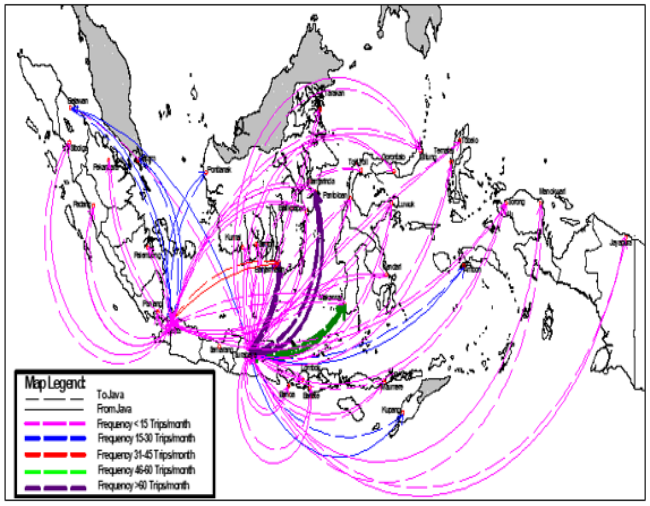
where, G is the index of spatial concentration, x_i and x_j is loading (unloading) in port i and j respectively. The spatial concentration index will be applied to measure changes in loading and unloading concentrations of ports i and j, and w_{ij} represents the existence of linkage between port i and j. In the case of binary weight matrices, the row of weight matrices wr_{ij} is standardized in the form:

$$wr_{i,j} = \frac{w_{i,j}}{\sum_j w_{i,j}}$$

IV. DOMESTIC AND INTERNATIONAL TRADE OF INDONESIA

Based on data from the Directorate General of Sea Transportation of the Ministry of Transportation, in 2015, more than 80% of loading and unloading of domestic goods transported was concentrated in Java, Sumatra, followed by Sulawesi and Kalimantan. Government policy in the maritime sector is directed to strengthen the connectivity between ports in various regions in Indonesia. Based on the concept of sea-highway, the government proposed the Ports of Belawan, Tanjung Priok, Tanjung Perak, Makasar and Bitung to be navigated regularly by large freight vessels, from the west to the east and vice versa. Unloaded cargo at the hub ports is then delivered to feeder ports throughout the country. It has been argued that the lack of regular large-scale vessels that serve the remote eastern part of Indonesia has caused high transportation cost per unit of goods, which triggers the high price of consumer goods in the region. Cargo throughput is heavily concentrated in the ports of Java such as Tanjung Priok in Jakarta and Tanjung Perak in Surabaya.

In addition to hub ports, there are 25 strategic ports all over Indonesia. Figure 1 shows the connectivity of domestic sea transport between ports, Table I shows the loading and unloading of both domestic and international cargo. Table II shows container throughput of five hub ports. Considering that more than 90% of the trade volume is distributed through sea transportation, the volume of international trade is closely related to the fleet of maritime transport. Based on the World Fleets data of 2016 by UNCTAD, Indonesia is ranked 23rd in the world's maritime transport fleet, sharing 0.96% of the world's maritime transport fleet. Given the condition of Indonesia as an archipelagic country with the fourth largest population in the world, the number of owners of vessels is small. Indonesia's number is even smaller compared to some countries that have a smaller territorial sea. In addition to ship ownership, another indicator that can be used to observe the performance of maritime transport is the throughput rate of container terminal. The port of Shanghai in China is the world's highest output with 36.54 million TEUs by 2015. Eight of the 15 ports with the highest output in the world are located in China. The two largest ports in Southeast Asia with the largest output are the Port of Singapore and Port of Klang in Malaysia.



Source: T. Achmadi, Nugroho, S, and Hadi, F, (2012), *Connectivity Report on Domestic Sea Transport*, Surabaya, LPPM–ITS and the World Bank Group

Fig. 1. Connectivity of domestic sea transport in Indonesia

TABLE I. LOADING AND UNLOADING STRATEGIC DOMESTIC PORTS

	Strategic Ports	International Unloading (ton)			International Loading (Ton)		
		2005	*2010*	*2015*	*2005*	*2010*	*2015*
1	Lhokseumawe	61	220	18	10,675	-	911
2	Belawan	2,967	2,963	2,389	4,275	3,380	3,403
3	Teluk Bayur	326	270	664	3,348	3,741	3,118
4	Dumai	1,077	695	414	16,263	4,310	9,113
5	Pekanbaru	451	323	86	2,185	563	177
6	Tanjung Pinang	8	54	581	4,455	82	1,646
7	Batam	450	2,529	2,870	239	2,088	6,720
8	Palembang	267	509	24	3,554	1,619	37
9	Panjang	1,241	1,330	1,811	4,085	4,702	2,541
10	Tanjung Priok	11,739	14,034	16,359	7,623	4,778	3,364
11	Banten	2,052	1,353	1,429	131	92	145
12	Tanjung Emas	986	1,234	7,772	348	169	466
13	Tanjung Perak	6	6,295	20,266	1,615	817	2,022
14	Benoa	-	-	41		8	3
15	Tenau	-	-	1,095		-	1,034
16	Pontianak	324	110	9	851	504	90
17	Banjarmasin	86	150	114	14,157	45,468	62,129
18	Balikpapan	181	3,604	3,609	9,458	16,244	16,160
19	Samarinda	59	101	33	11,938	47,992	38,875
20	Bitung	20	27	58	824	204	231
21	Makassar	678	1,668	1,353	1,56	497	220
22	Ambon	-	6	-	4	-	-
23	Sorong	9	-	-	109	3	-
24	Jayapura	-	-	-	-	-	-
25	Biak	-	-	-	-	-	-
	Total	28,992	37,475	60,995	97,697	137,261	152,405
	Total all ports	50,386	65,641	98,858	160,743	233,222	340,001

Source: Processed from Central Statistical Office

TABLE II. INTERREGIONAL CONTAINER THROUGHPUT IN FIVE HUB PORTS (TEUS)

HUB PORTS	Belawan	Tg Priok	Tg Perak	Makasar	Bitung	Total
Belawan	-	225,689	62,277	1,391	2,535	291,892
Tanjung Priok	3,141	-	152,285	195,798	8,224	359,448
Tanjung Perak	59,705	246,010	-	199,030	35,742	540,487
Makassar	2,886	249,249	303,220	-	24,896	580,251
Bitung	-	64,490	89,633	4,435	-	158,558
Total	65,732	785,438	607,415	400,654	71,397	1,930,636

Source: Ministry of Transportation

If the ports are grouped by country, Indonesia is ranked 12th with a total density of 11,900,763 TEUs by 2014. Within 14 years, the container terminal traffic density in Indonesia has increased by 213.35%. Nevertheless, the rate of increase is still slower than some neighboring countries in ASEAN, namely Vietnam (701.07%) and Malaysia (389.37%).

Observed from the number of export and import of commodities. The three main sectors that dominate Indonesia's import-export are the agricultural, fuel & mining, and manufacturing sectors. Japan, China, the EU, and Singapore are Indonesia's biggest partners in international trade.

Based on the export volume of containers, Indonesia ranks fifth under China, the United States, South Korea, and Japan. China, ranked number three, has tripled its export volume; leaving the United States in the second rank. The volume of Indonesian container export is only 11% of China's export volume in 2014. However, this value is still the highest among ASEAN members. Indonesia

outperformed Thailand, Vietnam, Malaysia and Singapore in terms of container exports. The high value of throughput rate and Singapore container traffic density contrasts with the low export-import value of containers in the country. This shows Singapore's position as one of the most important international container distribution channels.

In the last ten years, the number of national fleets increased from 6,041 units in 2005 to 11,645 units in 2015. Improvement in the performance is also shown by the increasing number of shipyards to about 250 companies that spread across Indonesia, namely Java (37%), Sumatra Island (26%), Kalimantan (12%) and eastern part of Indonesia (12%). The shipyard has a production capacity of approximately 1 million dead weight tons (DWT) per year for new vessels and about 12 million DWT per year for repairing.

The potential market of the national shipping industry is actually very large. This is indicated by the high demand for international and inter-island trade that reaches 400 million tons per year. However, the market share of the national shipping industry has not been well developed and is still in the range of 0.3% to 0.5%. This number is still relatively low compared to other ASEAN countries such as the Philippines (2.6%) and Vietnam (1.1%), or with major players in the world shipping industry, China (41%), South Korea (33%) and Japan (18%). This condition is caused by the limited capacity of the national fleet that is still dominated by small to medium vessels [14].

V. DATA ANALYSIS

Based on loading and unloading data, both domestic and international cargo in 25 strategic ports of Indonesia between 2005 and 2015, using standard Gini index, there is indication of greater concentration of unloading of domestic cargo especially between 2006 and 2014 (Table III and Figure 2). This may indicate that some ports have played a more important role as a port of destination. At the same time, the concentration index for cargo loading tends to be stable during the same period.

TABLE III. GINI COEFFICIENT DOMESTIC AND FOREIGN TRADE IN STRATEGIC PORTS IN INDONESIA

YEAR	DOMESTIC TRADE		FOREIGN TRADE	
	Unloading	*Loading*	*Unloading*	*Loading*
2005	0.5837	0.6976	0,8009	0,6418
2006	0.5574	0.6921	0,7060	0,6987
2009	0.5978	0.6527	0,7665	0,7932
2010	0.6308	0.6881	0,7550	0,8170
2014	0.7157	0.6493	0,7945	0,8192
2015	0.7068	0.7069	0,7876	0,8120

The application of spatial Gini method shows that out of 0,6290 Gini coefficient, more than 65% of the disparity is contributed by interregional connection (Table V). It can be decomposed into loading and unloading where in interregional connection itself, unloading container cargo contributes more than 48% of the disparity.

Concentration index using Gini coefficient, however, fail to show the dynamic changes of cargo loading and unloading of a pair of origin and destination ports in the system, to see if certain ports have played a more dominant role. As shown in Figure 3, in general, the concentration index of loading and unloading of foreign trade is higher than the index for domestic trade.

It is interesting to note that using standard Gini coefficient, overall, the Gini coefficient is 0,6355 for container throughputs in five hub ports (Table IV). The largest percentage of the disparity is contributed by unloading (0,4093) compared to loading (0,2262). It means that the destination of container cargo is concentrated in certain ports compared to ports of origin.

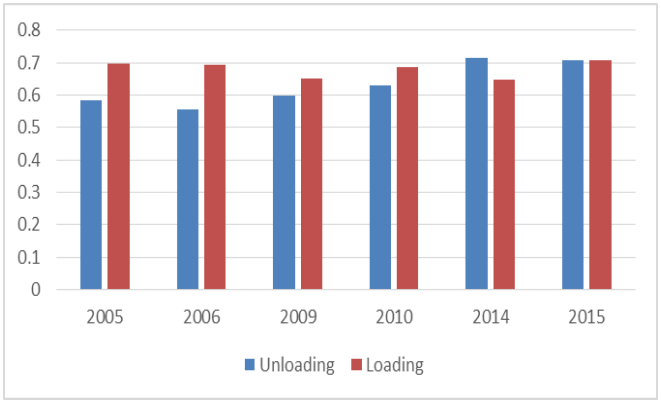


Fig. 2. Concentration Index of loading and unloading of Inter-island cargo

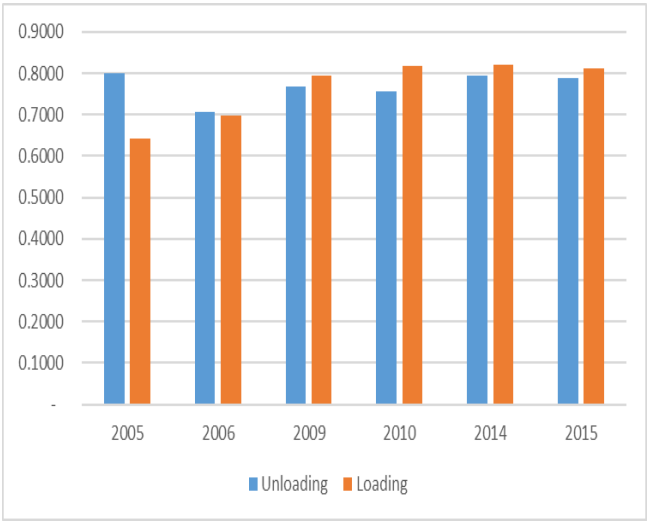


Fig. 3. Concentration index of loading and unloading of foreign cargo

TABLE IV. GINI COEFFICIENT OF FIVE HUB PORTS

YEAR	GINI COEFFICIENT	
	Unloading	*Loading*
2015	0.4093	0.2262

TABLE V. SPATIAL GINI COEFFICIENT OF FIVE HUB PORTS

YEAR	SPATIAL GINI COEFFICIENT				
	Intra-regional		*Interregional*		*Total*
	Loading	Unloading	Loading	Unloading	
2015	0.0462	0.0991	0.1794	0.3042	0.6290
%	7.35	15.76	28.52	48.37	100.00

One of the explanations of the largest contribution of interregional connection in spatial Gini coefficient is the non-existence of direct connection between the Port of Belawan in North Sumatera and the Port of Bitung in North Sulawesi.

VI. CONCLUSIONS AND RECOMMENDATIONS

a. Using spatial Gini model, the concentration index of hub ports in terms of container loading (unloading) activities at five hub ports by 2015 indicates that the largest container transport concentration in five hub ports is due to unloading factors that are more concentrated in a particular destination port than the loading factor. The largest portion of container transport is focused on the Ports of Tanjung Priok and Tanjung Perak compared to other hub ports. This indicates that hub port in outer Java has not yet played a significant role as the port of destination.

b. Inequality of loading and unloading of cargo is mainly due to the interregional factor, which contributes 76.8% of the concentration index (0.6290). It is caused by, among other factors, the non-existence of direct connection between the Ports of Belawan and Bitung.

c. With the sea-highway policy, it is expected that the role of hub ports in outer Java will play a more important role both as origin and destination of cargo. Going forward, the spatial Gini approach can be used as one of the analytical tools to measure the dynamic changes in the role of hub ports in reducing the disparity between the Western and Eastern regions of the country.

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