Policy Research Working Paper 4911

Weathering the Storm

Investing in Port Infrastructure to Lower Trade Costs in East Asia

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Development Research Group
Trade Team
April 2009

Policy Research Working Paper 4911

Abstract

The world economic crisis of 2008 presents clear challenges to prospects for economic growth in developing countries. This is particularly true for emerging economies in East Asia that have relied to a great extent over the past decade on export-led growth. What steps to facilitate trade promise a relatively strong return on investment for East Asia to help sustain trade and growth? The authors examine how port infrastructure affects trade and the role of transport costs in driving exports and imports for the region. They find that port congestion has significantly increased the transport costs to East Asia from both of the United States and Japan. The analysis suggests that cutting port congestion by 10 percent could cut transport costs in East Asia by up to 3 percent. This translates into a 0.3 to 0.5 percent across-the-board tariff cut. In addition, the estimates suggest that the trade cost reduction of investment in port infrastructure in East Asia that translates into higher consumer welfare would far outweigh the cost for physical expansion of the ports in the region.

This paper—a product of the Trade Team, Development Research Group—is part of a larger effort in the department to explore the linkages between trade costs, facilitation, and economic development. This work is aligned with the project "Trade Facilitation and Economic Growth: The Development Dimension" in the Development Economics Research Group with support from the governments of Norway, Sweden and the United Kingdom through the Multidonor Trust Fund for Trade and Development. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at jswilson@worldbank.org and kabe@mail.dendai.ac.jp.

Weathering the Storm:

Investing in Port Infrastructure to Lower Trade Costs in East Asia

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1. Introduction

This paper examines how investment in port facilities affects trade costs and facilitation. We focus on developing countries in East Asia where international trade has played a major role over the past several decades in economic development. Port infrastructure has played a key role in facilitating trade in the region. However, serious congestion in seaports is evident from data on maritime shipping and trade. The scope of the study includes the costs, as well as benefits, of the construction of port infrastructure to address traffic congestion in East Asia. The paper also discusses the important role of port investment to stimulate demand and productivity, especially in a time of economic crisis.[2]

International Trade in East Asia

International trade in East Asia has grown more rapidly than other regions in the world over the past two decades. At the same time, rapid economic growth fostered development in the region (Table 1). In particular, ASEAN countries in the early 1990s and China after the late 1990s recorded remarkable growth in trade even as the Asian economic crisis had a negative effect on the economic growth and trade in the region for the late 1990s.

A number of studies have attributed various factors to the growth in trade; including rapid industrialization of developing countries in the region and an active trade liberalization and facilitation agenda tied to development plans. In turn, many studies have pointed out that expansion in international trade stimulated the economic growth. This mechanism also functioned in the early 2000s when most of the ASEAN member economies took the path of recovery from the crisis, and China emerged as a dominant exporter in the region. China's accession to the World Trade Organization in 2001 contributed to extremely high rates of growth in trade and direct investment. The regional trade liberalization in ASEAN, such as a free trade

[2] The issue of the impact of port infrastructure improvement on economic welfare and growth (through trade) in different countries is also an important empirical and policy question. This is beyond the scope of our analysis here; however, future work on welfare and growth impacts of improved port infrastructure would be helpful in a possible extension of this analysis.

agreement, is also suggested to have expanded intra-regional trade, contributing to economic recovery.

While the trade and investment liberalization stimulated trade in the region, various bottlenecks to the movement of goods hindered trade expansion. In particular, in East Asia, port infrastructure has an important role in supporting increases in trade by removing such bottlenecks.

Table 1: Growth of GDP and Trade in East Asia

	Nominal GDP			*Nominal Trade*		
	95/90	00/95	06/00	95/90	00/95	05/00
East Asia (ASEAN5 plus CJK)	12.4	-0.6	4.2	13.2	5.0	11.5
East Asia (exclu. Japan)	14.6	3.9	12.3	17.5	6.7	14.2
ASEAN5	13.7	-2.4	10.0	17.8	3.7	7.7
Indonesia	12.1	-4.0	14.1	12.9	3.7	7.2
Malaysia	15.1	0.3	8.7	21.1	4.2	7.3
Philippines	10.8	0.5	7.5	16.5	13.0	1.8
Singapore	18.0	1.9	6.1	18.2	2.7	7.9
Thailand	14.5	-6.1	9.0	17.8	0.9	11.6
Northeast Asia (CJK)						
China	15.5	10.5	14.3	20.5	14.3	24.6
Japan	11.7	-2.4	-1.1	7.9	2.0	5.4
Korea	14.4	-0.2	9.6	14.4	5.7	10.2
USA	5.0	5.9	5.2	8.4	8.5	5.2
Canada	0.3	4.2	9.8	7.5	8.1	5.4
EMU	5.1	-3.1	9.2	5.9	2.1	10.4
World	6.3	1.5	7.2	8.0	4.8	9.8

(Source) World Bank, *World Development Indicators*.

(Note) Unit: percent. Nominal GDP is in the current $US. Trade means the sum of imports and exports.

Regional Trade in East Asia

Intra-regional trade has increased as a proportion of the total exports in East Asia over the past decade. Table 2 below illustrates the shares of exports in selected sub-regions and countries in East Asia.

Table 2: Shares of Exports of the Selected Region and Countries in East Asia

		Importer						
exporter	*year*	*ASEAN5 + CJK*	*ASEAN5*	*China*	*Japan*	*USA*	*others*	*World*
ASEAN5+CJK	1985	29.3	9.5	7.7	9.0	32.9	37.8	100.0
	1990	31.1	12.5	5.5	9.0	28.1	40.8	100.0
	1995	39.5	16.8	8.9	9.1	24.7	35.8	100.0
	2000	37.4	14.5	9.1	9.3	26.5	36.1	100.0
	2006	38.7	13.3	12.5	8.0	20.9	40.4	100.0
ASEAN5	1985	54.0	19.4	5.4	26.0	22.1	23.9	100.0
	1990	49.6	19.5	6.9	19.8	21.5	28.8	100.0
	1995	52.7	24.6	9.8	15.1	20.9	26.3	100.0
	2000	51.7	23.4	9.9	14.4	21.2	27.1	100.0
	2006	58.2	25.6	17.1	11.6	15.2	26.6	100.0
China	1985	29.7	11.1	--	17.3	27.4	42.9	100.0
	1990	26.6	10.0	--	14.2	25.8	47.6	100.0
	1995	30.1	8.8	--	17.1	27.4	42.6	100.0
	2000	28.0	7.8	--	15.7	29.4	42.6	100.0
	2006	24.1	7.9	--	10.9	25.6	50.3	100.0
Japan	1985	21.2	6.4	10.8	--	37.6	41.2	100.0
	1990	24.2	11.5	6.7	--	31.7	44.1	100.0
	1995	35.6	17.3	11.2	--	27.5	36.9	100.0
	2000	32.3	13.8	12.0	--	30.1	37.6	100.0
	2006	38.9	11.1	20.0	--	22.8	38.4	100.0

(Source) International Monetary fund, *Direction of Trade Statistics*.

(Note) Unit: percent.

The United States and Japan have been the major destinations for exports from East Asia. China emerged as another major importer for the region. In contrast, the share of the United States has declined. Intra-regional trade in East Asia continued to be around 40 percent of the share of total exports since 1995. Including the United States, this ratio was around 60 percent since 2000.

For the ASEAN5, nearly 60 percent of the group's exports went to East Asia, and 73 percent, to East Asia and the United States in 2006. Intra-regional trade within the ASEAN5 has been on an increasing trend. A number of studies attribute this to the formation of transnational production network in the region. China emerged as the largest absorber of exports from ASEAN5 after 2000, passing Japan and the United States as the largest importers of goods from these countries. While the presence of the United States is still large, the intra-regional trade of East Asia as a whole, represented by ASEAN5 plus China, Japan and Korea, was on an increasing trend after 1990.

The Important Role of Ocean Ports in the Trade of East Asia

Countries in East Asia need to rely heavily on ocean transportation as the means of international trade. Among the ASEAN5, the peninsular part of Malaysia, Singapore and Thailand are adjacent to each other, but significant amounts of the trade among them must rely on ocean transportation. Indonesia and Philippines are islands countries. If measured by weight, virtually all the traded goods between the ASEAN5 and all of the major trading partners, the United States, Japan and China, need to move through ocean. Road and railway transport between China and some ASEAN5 members contributes to their trade, but it is limited, because a major part of the international trade takes place between the industrial center of China, i.e. its coastal provinces, and ASEAN5. Air transport is rapidly increasing and taking a substantial share, especially in trade value. The dominant volume of trade of the developing countries still relies on sea transport. For example, the share of air over the total imports of the United States from ASEAN5 countries reached 56.3 percent in value, but only 1.4 percent in weight in 2006.[3]

Reflecting the geographic characteristics noted above, governments in East Asia have historically set a priority on port infrastructure improvements -- in coordination with an export-oriented development strategy. Transport infrastructure has also been a key sector in ODA in East Asia. More recently, the improvement of port infrastructure plays a major role in the trade facilitation initiatives in the processes of Asia Pacific Economic Cooperation (APEC) and the WTO. Shortage in port capacity and quality in the developing countries in this region, however, has risen over the past decade.

[3] A detailed comparison of port infrastructures in East Asia compared with other regions is beyond the scope of this analysis. As of May 2007 reported in Efluxmedia Asian ports held the six top spots in the world in regard to TEU for container traffice.

Containerization as Technical Progress

Containerization has involved significant technical progress in ocean freight transport since its introduction in the 1960s. It moved rather slowly to developing countries from the late 1970s, reflecting the capital intensive nature of this technology (Hummels (2007)). Containerization of cargo facilitated transportation with standardization of loading and unloading and reduced transport costs through faster and higher quality transportation networks. In 2006, containerized cargo in weight represented 39 percent of total ocean cargo from the ASEAN5 to the United States compared with 31 percent in 2001. Containerization steadily expanded in spite of the moderate pace of expansion during these periods[4].

The ratios of containerization of total vessel cargo in 2005 reached more than 80 to 90 percent in the major and recently constructed or upgraded ocean ports in East Asia: e.g. Singapore, 93 percent; Hong Kong, 90 percent; Osaka (Japan), 100 percent; Laem Chabang (Thailand), 96 percent; Port Kelang (Malaysia) 90 percent; Manila (Philippines), 84 percent; and Keelung and Taichung (Taiwan), 96 percent. These sites have the most container-specialized berths and loading facilities and are mainly used for international trade. Other major ports in East Asia have been also equipped container facilities. This includes those in Japan and Korea. New ports in China, such as those in Shanghai, Dalian, Nimbo, and Qindao have container berths that are deep and equipped to accommodate the latest large container vessels.

Since the late 1990s, developing countries in East Asia actively constructed and dredged container ports with deep berths and large automated cranes. This construction accelerated in the 2000s when trade expanded rapidly in the region. Container berths more than 14 meters deep can accommodate vessels with nearly twice as large a capacity as those 13 meters or less deep. The larger container vessels, together with deepened container berths, help address the growing demand in trade of East Asia for improved efficiency in ocean container freight traffic. This is a

[4] The import via vessel includes bulky natural resources via tankers or trumps and other goods not suitable to the container transportation. With the existence of these bulky imports, the containerization ratios in East Asia, 31 percent, is not particularly low. For example, the ratios from Philippines and Singapore are 62 percent and 76 percent, respectively.

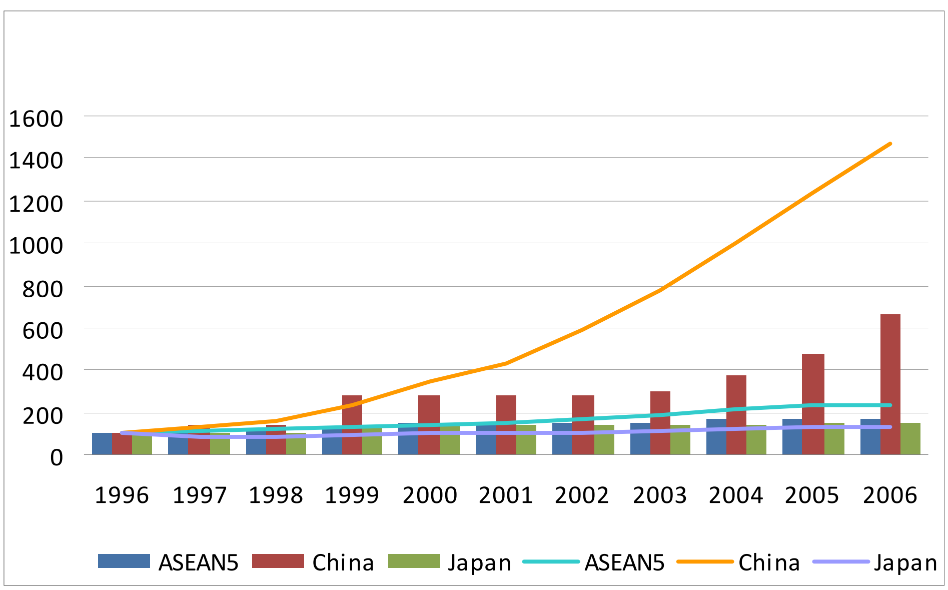
type of embodied technical progress with which the construction of new ports and expansion of berths can bring about both increased capacity and improved efficiency.

Containerization contributes to reducing transport costs. Empirical studies of this issue, however, have found that declines in transport cost due to wider use of containerization have likely been modest. On this point, Hummels (2007) suggests the possibility that technology raised the quality of transportation, but the price indices of ocean transportation does not reflect better quality. Moreover, Hummels, referring to the empirical result on the estimated elasticity by Blonigen and Wilson (2006), also shows that the amount of cost cuts from containerization should be limited.

Trends in Port Traffic in East Asia: Expanded Capacity but More Congestion

The major ocean ports in East Asian developing countries have suffered from serious congestion with rapid growth in freight demand over the past decade. Bottlenecks arise in spite of continued investments in port improvement, expansion and containerization. Figure 1 illustrates the trends in capacity and throughput in the major container ports in ASEAN5, China and Japan.

Figure 1: Capacity and Throughput in Major Container Ports



(Source) Authors' estimates. *Containerization International Yearbook*, *Shipping Statistics Yearbook.*

(Note) Index at 1996 =100 . Bar graph denotes the sum of the estimated capacity of the major container ports in the country / region. The numbers of major ports are: 8 in ASEAN5, 8 in China, and 11 in Japan. See Appendix for the detailed methodology of the estimation of the port capacities. Line graphs in the figure denote the sum of the loaded and unloaded containers in TEU.

Port traffic in ASEAN5 has steadily grown, while the Asian economic crisis slowed this trend around 2000. The growth of port traffic throughput, measured as total unloaded and loaded containers in TEU, has consistently exceeded that of the physical capacity of the ports. China has had growth in port traffic, by 30.8 percent annually from 1996 to 2006, much faster than experienced in ASEAN at 9.0 percent. The investment in port infrastructure could not keep pace with the growth of port capacity during the same period, 20.8 and 5.3 percent on annual average respectively. Because of the resulting congestion, vessels needed to wait for embarkation and disembarkation. Ports in Japan, in contrast to the ASEAN5 and China, have had idle capacity. Reflecting the long period of stagnation in the Japanese economy, Japanese trade grew slowly. Substantial public investment in 1999 and 2000, due to the counter-cyclical fiscal policy of the Japanese government, contributed to increases in port capacity. These factors, together with substitution to air transport, have led to idol port capacity in Japan.

Ports with sufficient capacity, efficient facilities with high technology, and good management contribute to lower transport and trade costs. In addition to the explicit costs from port tariffs and loading / unloading charges, the time costs from congestion and inefficient facilities / management contribute to transport costs. These costs are reflected in freight charges by shipping companies, storage costs, and brokerage fees by port broker incurred by traders. More frequently, these costs are charged to traders in payments to forwarders. Our study examines whether and to what degree improvement in port infrastructure in East Asia has reduced the total costs of port transportation over the past decade. It also examines whether the investment to expand capacity will cover cos*ts*

The Economic Crisis and Port Infrastructure in East Asia

The economic crisis is affecting the economies in East Asia in a number of ways. This includes a sharp decline in exports and restricted access to finance. With a multiplier effect, the economies in East Asia, including China and Japan, fell into recession at the end of 2008 and reduced intra-regional trade. It has been reported that about 10 percent of container ships have been idle during this period. Some shipping companies expect the decline in volume in 2009 may reach 20 percent. Chronic port congestion may be lessened at some ports for some period in the region. Full recovery in the United States, Japan and Europe over the short term is unlikely. As a result, exports of the developing economies in East Asia will not likely return to the high levels in 2008.

The decline in demand for international transportation suggests a decline in the expected rates of return in new investment in port infrastructure.. This may hinder some of the port development projects that had been viable prior to the crisis. However, since infrastructure projects require a long gestation period and cost recovery is expected over a long time period; demand and rates of return should be considered from a long-term perspective. One should note that the demand for ports in the region does not only depend only on demand in the United States or Japan. Over the long term a shift from external to internal and regional demands may take place.

As long as port development projects are viable in the long-run, investment in ports likely provides a good policy target in the region both in terms of creating macroeconomic demand and improving supply side growth prospects. Investment in port infrastructure in developing economies in East Asia could have a strategic role in this regard. The following sections of this paper center on the benefits and costs of increased port capacity within the context outlined above.

2. Port Infrastructure, Transport and Trade Costs: Survey

Trade costs are widely defined as any costs which increase the prices of traded goods during the delivery process from the exporters (or producers) in exporting countries to the final consumers. Developed countries face substantially high international trade costs: estimated about 74 percent in terms of *ad valorem* tax equivalent[5], including transportation costs, policy barriers,

[5] Defined as international trade costs divided by the value of the imported goods in the country of origin.

information costs, contract enforcement costs, currency costs, and legal and regulatory costs[6] (Anderson and van Wincoop (2004)). Poor countries have higher trade costs. The quantity and quality of port infrastructure closely affect transport costs. Expansion of port capacity and improved port facilities can streamline and speed-up embarking and disembarking, loading and unloading process and enable to use more efficient container vessels. This section surveys the existing literatures on the infrastructure and transport costs, focusing on the empirical findings on the ocean ports, in particular.

Limited Availability of Trade Cost Data

The existence of trade costs is a key theoretical assumption of the standard gravity model of trade. Bilateral trade in the gravity model is determined by the magnitude of the economies of the trading partners and relative bilateral trade costs. A major analytical obstacle to this model is the limitation of official statistics on the trade cost, which prevents the researchers from directly regressing the bilateral trades on the amounts/rates of trade costs in total. As a compromise, proxy variables – such as distance, required time for trade, geographical and policy dummies, and various surveyed indexes – appear in the trade regressions, in addition to published nominal tariff rates. This enables us to estimate the effect of trade costs, represented by these factors, on trade. However, the degree to which these variables affect trade cost itself and the degree to which trade cost affects bilateral trade remain unclear.

The limitation in availability of the data is also true for the narrowly-defined transport costs between the ports that constitute a part of trade costs. The authorities of most countries only publish the amounts of import on the CIF base, inclusive of export prices of the goods and costs for insurance and freight without showing any details. If researchers would like international transport cost data between the ports of trade partners, they must estimate the international transport cost by separating that part from the CIF import prices in most of the countries. Only

[6] Even the lack of transparency in the trade policies would increase the trade costs because of higher risks in trade, obliging the traders to pay the premium for preventative measures in case the risks realize. See Helbel, Shepherd and Wilson (2008), and Abe and Wilson (2008).

the United States and New Zealand officially publish shipping / transport cost data based on the declarations of the importers for the purpose of taxation[7].

Estimating trade costs for empirical analysis is challenging, therefore. An empirical compromise has been the "matching method" which uses ratio of the CIF import value divided by FOB export value between the same trading partners, whereas the former is reported from the importing country and the latter, from the exporting country. Limao and Venables (2001) estimate transport costs, or more precisely the "transport cost factors" by applying the method to the Direction of Trade Statistics (DOT), published by the International Monetary Fund (IMF). The authors use estimated transport cost factors as the dependent variable of the regressions to examine various determinants of transport costs, which include an index of infrastructure level. While they appear to obtain a persuasive result, the matching method should require a careful treatment in use. For instance, Hummels and Lugovskyy (2006) analyze the accuracy of the method, comparing the estimates with the officially published import charges statistics of the United States and New Zealand, concluding that the matching method may generate "noisy" information.

Determinants of Transport Costs

Limao and Venables (2001) estimate determinants of transport costs, in particular those related to infrastructure. Their transport cost factor regression has distance, per capita incomes, geographical factors, such as common barriers and island dummies, and the indexes of the levels of infrastructure of various parties, as explanatory variables. Their infrastructure index consists of four items: (i) length of road, (ii) length of paved road, (iii) length of rail, and (iv) telephone main lines per person. These four items are normalized and averaged to construct the infrastructure index of a country. Due to its main interest in transport costs for the geographically landlocked counties, the study tends to be implicit on the port infrastructure. But the regressions of trade costs and bilateral trade amount both include the dummy variable for inlands, partially controlling the effect of sea transport. According to their findings, sea transport is much cheaper than land transport. In contrast, explicit measures of port infrastructure should be necessary in

[7] A few countries appear to have transport data in cross-section (Hummels and Lugovskyy (2006)).

our study on East Asia where the dominant proportion of the trade in volume is made between sea ports.

Another implication of Limao and Venables (2001) concerns the level of infrastructure development in both trading partners and transit countries and that these can have a significantly negative effect on transport cost factors regression. If a country can improve its infrastructure level from the median to the top 25th percentile, the transport cost factor of the country would fall from 1.28 to 1.11. This is equivalent to becoming 2,358 km closer to all the trading partners, with the estimated elasticity of distance about 0.38. Moreover, the pseudo-R^2 shows that the distance alone explains only 10 percent of the variation of transport costs. The other geographical factors and infrastructure explain the larger part of the variation in transport costs, showing their significance.

Clark, Dollar, and Micco (2004) specifically examine the relationship between port efficiency and maritime transport costs. Instead of using the CIF/FOB matching method, they directly use the "import charges" from the United States trade statistics. The U.S. official statistics record every year the HS 6-digit commodity based, via liners, port-to-port import values, weights and "import charges", the latter roughly reflecting the transport costs between the ports[8]. They run regression analysis for cross-section data in 1998: the dependent variable is port-to-port via-liner import charge per weight at HS 6-digit commodity level; the independent variables are bilateral (port-to-port) distance, port-to-port via-liner trade value per weight at HS 6-digit level, total import volume from the exporting country, directional imbalance in total trade between the U.S. and the exporting country, containerization ratio of the HS 6-digit based import from the exporting country, and various policy variables, as well as the efficiency indicators of sea ports of exporting countries to the ports of the U.S. [9]

[8] According to the official source, the import charge represents the aggregate cost of all freight, insurance, and other charges (excluding U.S. import duties) incurred.

[9] The amounts of the trade and weight in their regression cover those transported by liners only, not include those by tankers nor tramps. They use an Instrumental Variable technique to control the endogeneity of the variable of total volume, with the instrumental variable of exporting country's GDP.

The authors test four different indicators as proxies of the port efficiency, including: (i) country specific port efficiency index from *The Global Competitiveness Report*[10]; (ii) total square number of largest seaports by country, normalized by the product of exporting country's population and area; (iii) GDP per capita of the exporting country; and (iv) the same infrastructure index as that used by Limao and Venables (2001). Their regression shows that all the four port efficiency indicators have significantly negative coefficients. The improvement in port efficiency leads to reduction of the transport costs. For other variables, the containerization ratio, directional imbalances and total liner import volume have negative coefficients, while distance and weight value have positive ones. The signs of the coefficients agree with the theoretical prediction.

Blonigen and Wilson (2008) adopt an innovative methodology to estimate the efficiency of major ports in the world including the United States. Using the port-to-port, HS 6-digit commodity based import statistics of the United States, this study explored the efficiency of trading partners' ports by estimating the regression of port-to-port import charges on partner's and U.S. port-specific fixed effects, as well as a explanatory variables. Their regression has port-to-port U.S. import charges in HS 6-digit commodity codes, as the dependent variable; and the dummy variables of the partner's and U.S. ports, the distance, weight, value per unit, containerization ratio, trade imbalances and some of the products of the variables, as independent variables.

The exporters' port-specific dummy variables in the regression should reflect their fix-effect, i.e. the cost efficiency/inefficiency for each port of the trading partners with the ports in the U.S. Then, they test the estimated port efficiency measures by applying them to the regression of port-to-port bilateral trade gravity model, as an explanatory variable, obtaining a significantly negative coefficient. This confirms that their estimated port efficiency measurements reflect the transport costs, which have an explanatory power on the bilateral trade.

[10] *The Global Competitiveness Reports* of the World Economic Forum publish every year the questionnaire survey results on various items related to the country's competitiveness, including the port efficiency indicators to measure the quality of infrastructure of ports and airports. The indicators reflect more or less subjective views of the respondent executives in the countries, as they are asked to respond by assigning points on the efficiency in their countries.

The port efficiency measures by Blonigen and Wilson show that, in East Asia, Japanese ports are generally more efficient. Those in Korea, Taiwan, Singapore and Hong Kong are less efficient. And those in Southeast Asia and China are the least efficient. However, their ranking of the port efficiency may attract an observation on the nature of the measurement. Some of the most technically advanced ports in East Asia, such as Singapore and Hong Kong come in the middle of the list[11]. As shown in Figure 1, the ports in the developing countries in East Asia chronically congested. The leading ports in the region, such as Singapore and Hong Kong generally charge higher port tariffs, reflecting their market power, high demands and superiority in technology. On the other hand, the ports in Japan that are higher-ranked in efficiency generally maintain idle capacity with smaller demands.

As such, the measure of port efficiency appears to strongly reflect not merely the technical efficiency, but the costs in total, including both pecuniary port tariffs and charges and the implicit time costs from the congestion and inefficiency in all the process in the ports. Moreover, the higher demand and technical efficiency may bring about rent on the port tariffs. Reflecting them, the port efficiency measurements by Blonigen and Wilson cover more than “the inherent technical efficiency of a port”, reflecting other non-technical factors to determine the costs around the ports, as also observed by the authors. Our research objective calls for direct measurements to reflect the physical capacity of port infrastructure, instead of adopting their measurement. Notwithstanding, their measurements provide a good reference with rich information on the cost efficiency of the ports in a wider sense.

A survey article by Hummels (2007) also addresses the determining factors of *ad valorem* transport costs[12] from the U.S. statistics. In the regression, the dependent variable is the *ad valorem* transport cost on the SITC 5-digit commodity base; and the independent variables include distance, weight per value, and fuel costs; running two separate regressions, namely air shipments and ocean shipment. The specification of the regressions of air shipments includes time-trend and an interaction term between distance and time trend, in addition, while that of ocean shipment includes containerized share of trade. The regression does not contain any

[11] For example, Singapore continues to take the top in the ranking of port infrastructure quality index in *The Global Competitiveness Report*.
[12] Defined as: (Import Charge) / (Import in FOB price). This measure is analogical with the *ad valorem* tariff rate.

variable representing the infrastructure, but signs of the other coefficients reinforce the former references.

Summary on the Estimated Elasiticities of Transport Cost per Weight

The estimated values of the elasticities of the determinant factors of transport costs in various literatures tend to converge within the consistent ranges. The elasticities reviewed below are converted to the elasticities of transport cost per weight with respect to the various independent variables, obtained from log-linear regressions. The summary below only refers to ocean transport, except mentioned otherwise.

- *Port-to-port distance*: around 0.14 to 0.21 for regressions on the disaggregated commodities base data. Only Limao and Venebles (2001), which uses the aggregated import charge data from matching method inclusive both ocean and land transportation, reports larger numbers: around 0.21 to 0.38. The larger numbers may reflect: (i) the higher cost land transportation; and (ii) the composition change effect that the longer distance results in comparative advantage in ocean shipping against the air, leading to higher value per weight ratio[13] and more expensive transport cost per weight.
- *Value per weight*: around 0.53 to 0.63. The elasticity is less than one, implying that the *ad valorem* transport cost decreases as the value per weight of the same commodity rises[14]. Within the same highly disaggregated category of commodity, transport cost takes smaller share in the sales price for the more expensive, luxurious goods.
- *Containerization ratio* (percent change of transport cost per weight with respect to the percent point change of containerization ratio): around -0.038 to -0.081. The estimate in terms of elasticity by Hummels (2007) is -0.29 in the pooled cross-country regression, and -0.134 if the cross-country difference is controlled.
- *Various Indicators for Port Infrastructure*: significantly contributing to the reduction in transport costs. One point rise in Port Efficiency in the GCR index[15] corresponds to 4.3 percent reduction in *ad valorem* transport cost. An increase in the number of major ports

[13] See Harrigan (2005) for the discussion on the comparative advantages between air and ocean shipping.
[14] The elasticity of *Ad valorem* transport cost with respect to value per weight equals to the elasticity of transport cost per weight with respect to value per weight minus one.
[15] The full mark of the index is 7.

from 3 to 4 in a country corresponds to 0.7 percent reduction in *ad valorem* transport cost. An upgrade of the *infrastructure index*, consisting of paved road, railroads and telephone lines also reduces the ocean transport cost, while the index is a proxy of the port infrastructure.

Ad Valorem Transport Costs in East Asia

The conclusion of this section outlines international transport costs in East Asia drawing on data from the United States and Japan since 2000. As noted above, U.S. official statistics report import charges aggregated at the detailed HS commodity classification. In addition, Japan, another major importer for the developing countries in East Asia, publishes official Balance of Payment (BOP) Statistics which include import amount on the FOB base[16]. Subtracting the FOB import in the BOP statistics from the CIF import in the customs statistics gives the estimate of transport cost of Japan.

The authorities in Japan, Ministry of Finance and the Bank of Japan, publish the data disaggregated by the exporting partners, but not in commodity subdivision. In the compilation of the official statistics, the authorities in Japan estimate the freight and insurance cost for the import from each country first, and then calculates the FOB imports by subtracting it from the reported customs values. With the ministerial ordinance, Japanese sea transport enterprises must report their revenues to the authorities, including import sea freight fare from the importers in Japan. Dividing the total amount of freight fare by the share of import sea cargo carried by the Japanese enterprises in the official maritime statistics, the authorities estimate the total amount of freight costs. This calculation is made on the exporter country-specific and modal-specific (liners, tramps and tankers) base, adding them up to country specific freight payments in total (Bank of Japan (2005)).

Table 3 summarizes the *ad valorem* ratio of import charges over the amount of imports from selected East Asian countries in the United States and Japan, averaged for 1996-2000 and 2001-

[16] Japan is one of the few countries which publish the FOB base import data in conformity with the *Balance of Payments Manual* of the IMF.

2006. Note that the data cover all the modals of the imports, including air, ocean and land shipments.

Table 3: *Ad valorem* Rates of Import Charge

(Unit: percent)

	Japan		*United States*	
	1996-2000	2001-2006	1996-2000	2001-2006
Indonesia	7.34	7.13	7.12	7.68
Malaysia	11.10	11.54	2.93	2.93
Phlippines	15.69	17.64	3.57	4.37
Singapore	7.34	6.81	1.68	1.80
Thailand	14.30	15.94	4.81	5.82
Viet Nam	12.83	11.23	7.33	8.28
China	7.65	9.29	6.46	6.72
Korea	10.91	14.27	3.36	3.79
Hong Kong	28.29	na	4.08	4.69
Taiwan	16.11	21.32	3.92	4.32
Canada	7.41	7.48	1.79	1.49
Australia	8.18	6.54	6.13	4.78
New Zealand	9.35	11.81	9.36	7.36
Japan	--	--	2.53	2.67
United States	13.43	13.89	--	--

(Source) Japan: Customs Office, Bank of Japan, US: Department of Commerce

(Note) 1. The rates are defined as: (Import Charge) / (Import in FOB/Custom Value) * 100.

2. The Bank of Japan reported negative imports from Hong Kong for 2003-2006, and the figures are omitted in this table.

Table 3 shows a significant difference between the levels of the rates reported by Japan and U.S. Japan generally reports higher rates of *ad valorem* transport costs than the U.S. The variations across countries do not correlate with each other[17], and do not appear to follow the exporters' relative proximity to the U.S. and Japan. The difference is smaller in Indonesia, Australia and New Zealand. Aside from the possible economic reasons, this difference in total may come from the sources of statistics: the import charges of the U.S. are declared by the importers who may be subject to strict supervision by the authorities, while the data of Japan are simply estimated on

[17] The correlation coefficient between the Japan and U.S. data across the exporting countries is -0.13 for the first period and 0.04 for the second period.

the information from the freight fare received by shipping companies. However, the formal regression analysis below suggests some other possible economic reasons.

Table 3 also suggests that *ad valorem* transport costs are generally higher than nominal tariff rates both in the United States and Japan. The simple average rates of nominal tariff of the United States and Japan are only 3.5 and 5.6 percent in 2006, respectively, according to the World Trade Organization Home Page. This underscores the relative importance of the trade facilitation to reduce such costs in the transportation sectors to promote the international trade.

3. Determinants of Transport Costs: Empirical Analysis

We conduct a formal regression analysis on transport costs in East Asia, using available data on transport costs, taken as import charges, of the United States and Japan. In line with our research interest, we include in the regression the explanatory variable representing the physical capacity of ports in the transport cost model to measure their effects. This section discusses the specification of the regression and the infrastructure indicators, and examines the results.

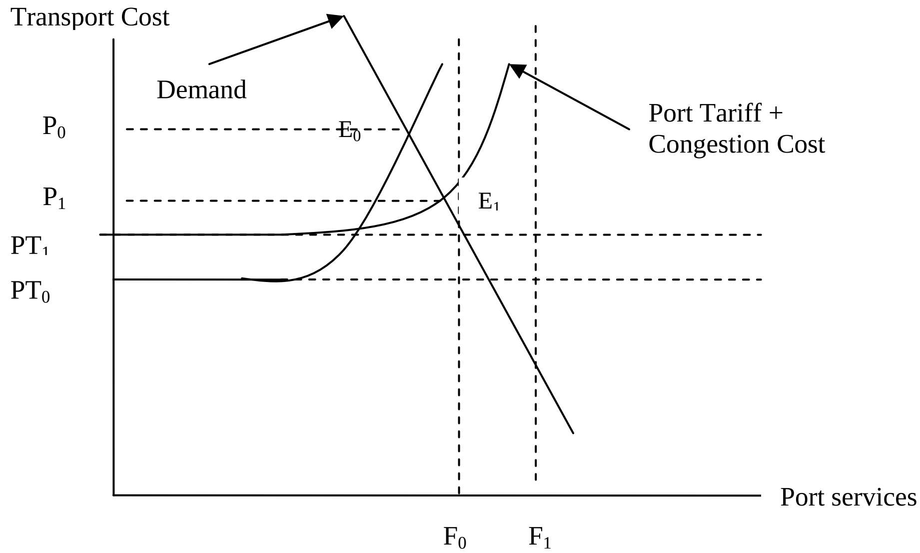
Port-related Costs Reflected in Import Charges

International transport costs between ports, defined by CIF minus FOB values, include only freight and insurance costs. But import charge statistics may cover the costs of services associated with transport: for example fees paid to port and storage brokers and freight forwarders. The comprehensive port efficiency index of Blonigen and Wilson, covering transport costs, is estimated from import charge statistics. If ports are congested not only do freight and insurance costs increase[18], but also miscellaneous costs to traders, such as idle time at ports[19], around the ports may further accumulate. Our empirical interest exists in the effect of expansion of physical port capacity which would reduce such costs.

[18] Costs for the fright companies may increase, due to longer waiting time for disembarkation and loading, and the increased uncertainty of the waste of time. These increased costs should pass on to the users.
[19] See Simeon, et.al (2008).

Figure 2 illustrates a simple partial equilibrium framework of supply and demand of the port services.

Figure 2: Market for Port Services: Illustration



(Note) P: Transport cost. PT: Port tariff. F: Full capacity of the port

The downward-sloping demand curve in the figure represents the demand for port services[20], which is in turn derived from the demands for the imports and exports of the goods through the ports of the country. The steep slope of the curve reflects somewhat inelastic derived demand. The supply curve of the port service represents the supply price from the port authorities to the users, i.e. the port tariffs and loading/unloading charges (PT), and the cost incurred because of the congestion / inefficiency in the port (P – PT). At the time 0, the equilibrium in the market is at E_0. With the lower full capacity of the port at F_0, the congestion cost is larger (P_0 – PT_0), in spite of the smaller port tariff at PT_0. If the port authority invests to expand the port capacity and upgrade port facilities, together with the new technology and management embodied and associated with the investment, the full capacity of the port increases to F_1. The port tariff (horizontal) part of the supply curve may shift upward to recover the construction costs[21], but the

[20] The users include the shipping companies, forwarders, and ultimately the traders of the goods. Due to our additional assumption of non-existence of rents by the shipping companies, the costs for the port service fully pass through to the importers without any mark-ups.
[21] The port authority may take rent, in addition to the capital cost, due to the superior services created from the investment.

upward-sloping part of the supply curve, representing congestion, shifts rightward and downward. At the new equilibrium E_1, both increase in the port tariff/charges and decrease in congestion costs take place. Only when the latter surpasses the former, this framework can consistently explain the negative coefficients of the port congestion.

Specifications and Data of the Trade Cost Regression: The U.S. Data

With the reference of the simple model illustrated above, we adopt the following specification for the regression model of the U.S. import charges per weight (equation (1)), which are similar to Clerk, Dollar and Micco (2004). The source of the data is *U.S. Imports of Merchandise*, DVDs, unless mentioned otherwise. The estimation period is from 2001 to 2006, when trade rapidly increased after the Economic Crisis and the congestion in the ports materialized.

$$\ln\left(\frac{TC_{ikt}}{Wgt_{ikt}}\right)=\alpha_0+\sum_k\alpha_{1k}+\sum_t\alpha_{2t}+\alpha_3\ln(dist_{it})+\alpha_4\ln\left(\frac{Value_{ikt}}{Wgt_{ikt}}\right)+\alpha_5\ln(Wgt_{ikt})+\alpha_6 Cnt_{it}$$
$$+\alpha_7 PIndex_{it}+\varepsilon_{ikt} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

where: TC_{ikt} : the amount of the import charge for the imports of the United States via vessels from country *i* for commodity *k* at 6-digit level, at the year *t*.

$dist_{it}$: bilateral distance between country *i* and the United States. The distance is calculated as the weighted average of the port-to-port liner distances between major ports in country *i* and Seattle, Los Angeles and New York, using the actual flows of container cargos in 1998 and 2003 as the weight (Shibasaki et. al. (2004)[22]). The distance estimated for 1998 is applied to the observations for 2001 and 2002, and that for 2003 is applied to those thereafter.

Wgt_{ikt} : the weight of the imports of the United States via vessels from country *i* for commodity *k* at 6-digit level, at the year *t*.

$Value_{ikt}$: the import customs value of the United States via vessels from country *i* for commodity *k* at 6-digit level, at the year *t*.

Cnt_{it} : the ratio of containerization, as the import weights via containerized vessels divided by those via all the vessels from country *i* at the year *t*.

[22] The authors appreciate the kind provision of the data in the electronic form from Dr. Shibasaki.

$PIndex_{it}$: the indexes representing the efficiency / capacity of the ports of the exporter country *i* at the year *t*. Our primary indicator for the regression is the port congestion index, defined as the sum of the loaded and unloaded containers in TEU at the major container ports in the country *i* in the year *t*, divided by the sum of the estimated full physical capacity of the major container ports in the country *i* in the year *t*.[23] This indicator reflects the ratio of utilization of the ports. The higher value of this index means the higher possibility of physical congestion in the ports. Accordingly, this index represents the supply curve drawn in Figure 2. For comparison purpose, we also test the port infrastructure quality index in *Global Competitiveness Reports* (*GCR*) and water transportation index in *The World Competitiveness Yearbook* of IMD (*WCY*).

α_{1k} : the dummy variables for controlling the commodity-specific fixed effects.

a_{2t} : the time dummy variables.

i: the exporting countries / regions in Asia Pacific region, consisting of each of ASEAN5 (Indonesia, Malaysia, Philippines, Singapore and Thailand), China, Japan, Korea, Hong Kong, Taiwan, Viet Nam, Australia and New Zealand.

Commodity-specific fixed effects and uniform time-varying factors across the country and commodity are assumed to exist in the regression. For the latter, time dummy variables enter the regression as explanatory variables, absorbing all the time-varying factors, such as changes in fuel prices and technological progress across the sectors and countries. All the independent variables appear to be exogenous, and we do not resort to the instrumental variable method, as is the case in the most of the existing studies.

Results of the Trade Cost Regressions of the U.S.

Table 4 below summarizes the results of the regression. As the observations represent the detailed subdivision of the commodities, the estimated parameters do not reflect the variation of composition of the imported commodities among the exporting countries. With the time dummies in place, the regression reflects only the cross-sectional variation. The commodity specific effects are also controlled by the fixed effects. The variables of distance, value/weight

[23] See Appendix A for the detailed methodology of the estimation of the port capacities.

and weight take the form in log, giving their elasticities. The containerization and port congestion indexes are in the form of ratio, and their estimated parameters represent the percentage change of import charge / weight, with respect to a point change in the indexes. Because of the lack of data on Viet Nam, the third specification uses fewer observations.

Table 4: Determinants of Trade Cost per Weight from Asia-Pacific Countries to the U.S.

	dependent variable: import charge / weight at 6-digits commodity level (log)		
	(1)	(2)	(3)
distance (log)	0.2470	0.0835	0.2105
	(10.84)***	(3.61)***	(9.39)***
value/weight (log)	0.4873	0.4909	0.4908
	(161.78)***	(163.62)***	(159.49)***
weight (log)	-0.0294	-0.0346	-0.0320
	(-32.32)***	(-37.56)***	(-33.66)***
containerization (share)	-0.0281	0.0169	0.0212
	(-15.25)***	(10.96)***	(12.71)***
port congestion (index)	0.0737		
	(18.45)***		
Port Infrastructure Quality		-0.0747	
(GCR) (index = 1 - 7)		(-33.95)***	
Water Transportation			-0.0517
(WCY) (Index = 1 - 10)			(-28.00)***
Numbers of Observations	151249	151249	145600
R^2	0.4057	0.4102	0.4111

(Source) Authors' estimates, using *U.S.A. Merchandise Imports DVDs*.

(Note) 1. Estimation period is from 2001 to 2006.

2. t-values in parentheses. *** significant at 1% , ** at 5%, * at 10%.

3. *GCR*: Global Competitiveness Report, *WCY*: World Competitiveness Yearbook.

4. For a reference purpose, the port congestion index in the regression is multiplied by a factor of 5000. This does not affect the significance of the estimates.

The first specification, using our port congestion index, takes the values of parameters on distance, value/weight, weight and containerization ratio generally within the comparable range to the existing empirical studies. In particular, more containerization saves the trade costs, but to a modest degree. The estimated parameter, -0.029, implies a bit smaller impact than the estimates by Hummels (2008), if converted into elasticity around average.

Our port congestion index takes a significantly positive coefficient. This is the expected result by our partial equilibrium framework, illustrated in Future 2 above. The estimated value implies that the expansion of port capacity by 19 percent in China, which is the annual average growth rate of the estimated port capacity from 2001 to 2006, would *ceteris paribus* reduce the international transport cost, measured by import charge, by 2 percent.

The other two indicators of port performance reflect opinion survey results. The *GCR* port infrastructure quality index reflects the responses on what degree port facilities and inland waterways in a country are developed, and the *WCY* water transportation index reflects the responses on to what degree water transportation (harbor, canals, etc.) meets business requirements. These indicators reflect the perceptions of the respondent executives in a particular country and generally cover a wider range of the scope than simply physical congestion of ports. Both of these indicators have significantly negative coefficients in the second and third specification of the regression, as expected. The estimated parameter on the *GCR* index, -0.074, is about double to that estimated by Clark, Dollar and Micco, -0.043, while there is difference in the *GCR* indexes with the latter being a discontinued index of the "port efficiency".

A one point increase in the port infrastructure quality index of the *GCR* would reduce transport cost by 7.4 percent. However, no country/region in our Asia Pacific sample could achieve the improvement as large as one point in this index between 2001 and 2006. The third specification using water transportation index of *WCY* results in similar estimates. The containerization ratio in the latter two specifications has positively significant coefficient, against the expectation. A possible explanation of this is that the two survey indicators may reflect the wider perception on water transportation, including the information of containerization. In fact, both of them positively correlate to the containerization ratio with coefficients around 0.5. After controlling the information in the survey indexes, the containerization ratio may just reflect the higher charges of containerized liners.

Comparison and Correlations between the Indexes on Ports

The three indicators on ports used above should reflect overlapping information. Table 5 shows the correlations between the three indicators and the port efficiency measures by Blonigen and Wilson (2008)[24] from 2001 to 2006.

Table 5: Correlations between the Indexes on Ports

	Port Congestion	*Port Infrastructure*	*Sea Transportation*	*Port Efficiency*
Port Congestion	1.00	--	--	--
Port Infrastructure (GCR)	-0.16	1.00	--	--
Sea Transportation (WCY)	0.02	0.92	1.00	--
Port Efficiency (BW)	0.29	-0.63	-0.47	1.00

(Source) Port Congestion: Authors' calculation based on *Containerization Yearbooks*. Port Infrastructure: *Global Competitiveness Report*. Sea Transportation: *World Competitiveness Yearbook*. Port Efficiency: Blonigen and Wilson (2008).

Our port congestion index partially correlates to the port efficiency measurement by Blonigen and Wilson. No significant correlation, however, is found with the indexes from *GCR* and *WCY*. Our port congestion index represents narrowly-defined physical congestion / utilization of ports and possibly some rents from the higher demands and technical efficiency. The other two indexes reflect survey opinions that reflect much a much wider scope and perceptions. Our index does correlate to the port efficiency index by Blonigen and Wilson which is supposed to cover all port-related costs incurred by transporters, because it is the value of the port-specific fixed effects. The indexes from *GCR* and *WCY* also correlate to the port efficiency index, showing that both of the indexes also contain information on the costs on ports.

If the port efficiency measurement of Blonigen and Wilson is regressed on our port congestion index, time dummies and constant, the estimated coefficient of our index is 0.049, significant at the 1 percent level. The regression can explain around 15 percent of the total sum of the squares. For the same example above, the expansion of port capacity by 18 percent for China in 2006 will brings about the fall in the port efficiency measurement by 1.3 percent. Because the port

[24] The journal article only puts a table showing a measurement averaged throughout the years from 1991 to 2003 on each foreign port. We take simple averages of ports in a country to obtain the index of the country, and assume the port efficiency measurements do not change over time from 2001 to 2006 to calculate the correlations in Table 5.

efficiency index is measured in terms of fixed effects in the regression of import charges, its fall by 1.3 percent just means the fall in import charges by the same percentage. The estimated results regression (1) implies that the same shock will bring about the fall in import charge by 2 percent. These comparable results from the two difference approaches reinforce the plausibility of our estimates.

Specifications and Data of the Trade Cost Regression: The Japanese Data

The same theoretical formulation as above can be applied to estimate the impacts of the port infrastructure improvement to trade costs by using the Japanese data. However, the constraint of the data in Japan to only the aggregated country level without the commodity and modal subdivision requires to the imposition of the various controls in regression. The estimation period covers from 1996 to 2006. The adopted specification for the regression is as follows in equation (2):

$$\ln\left(\frac{TC_{it}}{Wgt_{it}}\right) = \beta_0 + \sum_t \beta_{1t} + \beta_2 \ln dist_{it} + \beta_3 \ln\left(\frac{Value_{it}}{Wgt_{it}}\right) + \beta_4 \ln dist_{it} \ln\left(\frac{Value_{it}}{Wgt_{it}}\right) + \beta_5\left(\frac{AirValue_{it}}{Value_{it}}\right) + \beta_6 \frac{Wgttnk_{ik}}{Wgt_{it}} + \beta_7 PIndex_{it} + \beta_8 HKdummy + \mu_{ikt} \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

where: TC_{ikt} : the amount of the transport costs imported by Japan, estimated by imports in CIF value subtracted by imports in FOB value.

$dist_{it}$: bilateral distance between country *i* and Japan. The same method as the U.S. data is applied to adjust the distance in 1998 and 2003. The distance estimated for 1998 is applied to the observations from 1996 to 2002, and that for 2003 is applied to those thereafter.

Wgt_{it} : the weight of the imports of Japan from country *i*, including both the shipments via vessels and air, at the year *t*.

$Value_{it}$: the import customs value in FOB value of Japan from country *i* at the year *t*.

$Airvalue_{it}$: the import customs value in FOB value of Japan via air shipping from country *i* at the year *t*. This divided by *Value* makes the ratio of air shipment in value to be used to control the air shipments.

$Wgttnk_{it}$: the weight of the imports of Japan from country *i* with the HS codes from25 to 27 at the year *t*. The range of the code covers stones, cement plaster, ores, slag, mineral fuel, oil, and so on. These bulky goods are normally transported by tankers or tramps. This divided by *Wgt* makes the ratio of bulky goods shipments in weight to be used to control the bulky goods shipments.

$PIndex_{it}$: the indexes representing the efficiency of the ports of the exporter country *i* at the year *t*. We use our port congestion index, the infrastructure index in *GCR*, and the water transportation index in *WCY*. In addition, the port efficiency measurements by Blonigen and Wilson is used in this regression of Japanese data to test this measurements estimated from the U.S. data.

β_{1t} : the time dummy variables to control the effects of time-varying factors throughout the countries, such as the fuel prices, exchange rates and overall technological progress.

β_{8t} : the dummy variables for controlling the extraordinarily large trade costs estimated for the data in Hong Kong from 2003 to 2006.

i: the importing country/region to Japan, including each country of ASEAN5, China, Korea, Hong Kong, Taiwan, Viet Nam, United States, Canada, Australia and New Zealand.

As indicated above, we control shipments via air; and those of bulky commodities of HS#25-27, to single out the effects of the improvement of ocean container port capacities. The interaction variable, distance in log times value per weight in log, is included in the regressors to control the special geographical feature in Japanese imports, namely, the remote countries across the Pacific Ocean, such as Australia and Canada, are rich in natural resources and materials, and tend to export the bulky goods via cheaper transportation[25].

Results of the Trade Cost Regressions of Japan

Table 6 below summarizes the results of regression (2). The four columns in the table correspond to the uses of each indicator on ports. The estimation periods in some cases differ from the

[25] We have also tested the containerization ratio both in values and weights, but they do not have significant coefficients in most of the specifications.

others, due to the availability of the indicators. The estimated parameters in regression (2) have a different implication from those of the U.S. These parameters measure the effects from the difference across the countries and years in the composition of the traded commodities, as well as those from the difference in the various factors across the countries and years for each commodity. In contrast, the regressions on the U.S. data on these parameters measure the latter, only. In coherence with this, the dependent variable, trade cost per weight, covers all the imports, inclusive of those via vessel and air.

Table 6: Determinants of Trade Cost per Weight from Asia-Pacific Countries to Japan

dependent variable: (imports CIF - imports FOB) / weight in total imports from the country (log)				
	(1)	(2)	(3)	(4)
distance (log)	0.2850	0.8114	1.0075	0.4602
	(1.25)	(2.21)**	(3.05)***	(2.04)***
value/weight (log)	1.6799	2.6419	2.8732	1.9797
	(4.32)***	(4.44)***	(5.39)***	(5.21)***
*distance (log) * (value / weight) (log)*	-0.0835	-0.1900	-0.2231	-0.1278
	(-1.73)*	(-2.57)**	(-3.37)***	(-2.66)***
air shipment share	1.3533	1.5265	1.5595	1.6731
	(7.43)***	(6.25)***	(6.62)***	(8.46)***
HS25-27 share	-0.4155	-0.2691	-0.3932	-0.6320
	(-2.30)**	(-1.23)	(-1.88)***	(-3.29)***
port congestion (index)	0.0737			
	(1.90)**			
Port Infrastructure Quality		-0.0518		
(GCR) (index = 1 - 7)		(-1.61)*		
Water Transportation			-0.0760	
(WCY) (Index = 1 - 10)			(-2.82)***	
Port Efficiency (BW)				0.9277
				(3.38)***
Numbers of Observations	153	83	103	153
Estimation period	1996 -2006	2001-2006	1999-2006	1996 -2006
R^2	0.9693	0.976	0.9722	0.971

(Source) Authors' estimates, using *Balance of Payments, Customs Statistics* of Japan.

(Note) 1. t-values in parentheses. *** significant at 1% , ** at 5%, * at 10%.

2. GCR: Global Competitiveness Report, WCY: World Competitiveness Yearbook. BW: Blonigen and Wilson (2008).

3. For a reference purpose, the port congestion index in the regression is multiplied by a factor of 5000 . This does not affect the significance of the estimates.

The variables generally take the expected signs, while insignificant parameters result in some cases. The coefficients on distance take the larger values, compared to the estimated in the existing studies at around 0.1 to 0.4. However, the interaction term may adjust it. The average values of the value/weight variable (in log) of the trading partners to Japan are 4.3 for ASEAN5, 4.8 for China, 4.6 for Korea and 4.8 for the United Sates, but only 3.6 for Canada and 2.3 for Australia. Taking the values of the interaction terms in calculation, the elasticity of the distance is almost zero for the neighboring countries to Japan, but 0.1 to 0.4 for Canada and Australia, being in the remote location.

The value/weight variable takes the coefficients larger than one. However, as discussed above, the estimated parameters reflect the variation of the compositions of commodities and modals across the countries. Again, taking the interaction term into consideration, with the average value of the distance variable in log around 7.7, the elasticity of the value/weight would be around one on average, and certainly less than one for the remote countries. A percentage point increase in the shares of air shipments in value increase the total trade cost by 1.4 – 1.7 percent, reflecting higher freight charge by air. A percentage point increase in the share of the specific bulky goods with HS 25-27 in volume decrease the total trade cost by 0.3 – 0.6 percent, reflecting lower charges for the modals to transport these goods, normally tankers and tramps[26]. In sum, controlling the difference in composition of commodities appears to work well, if not perfectly.

The estimated coefficients on the indicators on ports in the Japanese trade cost regression take the expected signs. Their values resemble those obtained from the regression using the U.S. data. However, the estimated coefficients here represent the impacts on total transport costs including those both via vessel and air. If the factors represented by the port indicators affect the air transport costs to lesser degree than ocean transport costs, the estimated coefficients of the port indicators here should be naturally smaller than those on the U.S. The coefficient of our port congestion index takes exactly the same number as the U.S. regression. If we assume no impact of the port congestion on the air transport costs, a 1 percent reduction in our index is estimated

[26] The ocean shipments costs considerably vary among the modals: the freight charges per ton for Japanese imports are 9,785 yen for linter, 1,872 yen for trampers, and 1,308 yen for tankers (*Maritime Affairs Report 2004* by Ministry of Land, Infrastructure and Transport of Japan).

bring about a 0.10 percent reduction in the ocean transport cost.[27] The indexes of port infrastructure quality of *GCR* and sea transportation of *WCY* result in a bit smaller than the U.S. regression. Port efficiency by Blonigen and Wilson takes a bit less than one. Overall, the estimated coefficients on the port indicators for Japan are consistent with those in the U.S. regression, except for our port congestion index with a somewhat stronger impact on total transport costs.

Table 3 shows that *ad valorem* trade costs are generally higher in Japan than in the U.S., except for imports from Indonesia and Australia. Due to the difference of the compositions of the imported commodity and modal aggregation in the data, we cannot directly compare the regressions between the U.S. and Japan. However, the comparison of the values of the explanatory variables in the regressions may give several possible explanations. For example, for the *ad valorem* trade costs between the export and import of the pair of the United States and Japan in 2001-2006, their average difference is 1.65 in terms of natural logarithm. The air shipment ratio recorded 0.5118 for the import of Japan from the U.S., but only 0.2405 for that of the U.S. from Japan. This large gap should contribute about 0.4 (= (0.5118 – 0.2405) x 1.3533) to the difference in trade cost. In addition, the value / weight ratios in log are 4.845 and 4.486 for the U.S. and Japan, respectively[28]. As the elasticity of this ratio, after reflecting the interaction term, is around one, this factor would also contribute about 0.4 (= (4.845 – 4.486) x 1) to the difference. This observation suggests that about 0.8 (= 0.4 + 0.4), about the half of the difference in *ad valorem* trade cost should be attributed to the difference in transportation modals and composition of imported commodities and their prices. The remaining difference, mainly coming from the difference in the parameters, may be probably due to the preference of Japanese importers to the speed and quality of the transportation, provided by liners, airs and container cargos, for the higher-priced goods.

[27] The port congestion index is considered here as a real functioning variable, not a proxy of general infrastructure level. This prorating calculation is based on the following data: (i) the value of air shipments takes a 38 percent share in the total imports of Japan; and (ii) the *Ad valorem* trade costs for air and ocean shipping are 3 percent and 5 percent, respectively, in U.S. imports data.

[28] The measurement units are adjusted to yen per metric ton.

4. Benefits and Costs of Port Infrastructure Improvement in East Asia

What Are the Benefits and Costs of Port Construction?

With a considerable surge in demand for exports and imports, port authorities in the developing countries in East Asia rapidly expanded the capacity of their container ports in the 2000s. However, serious congestion remains. Our regression analysis suggests that the expansion of port infrastructure would *ceteris paribus* reduce the import charges / trade costs, ultimately paid by the importers. In turn, reduction in the transport costs may lead to an expansion of trade through the ports. The consumer surplus for the importers should increase.[29]

The partial equilibrium framework illustrated in Figure 2 above helps consider what happens to the welfare of the port users and port authorities. In the diagram, the increase in welfare is brought about by the decline of the port-related total transport cost from P_0 to P_1. The decline in the costs for port services is to pass through to the reduced charges of the international transportation services, such as forwarders, to the traders, which are recorded by the import charge statistics as import charges.

A hypothetical policy simulation can assess the net benefit of port capacity expansion in East Asia in terms of percentage change in trade costs. In our partial equilibrium framework, the net welfare gain due to the expansion of the port capacity equals to the sum of the increase in consumer surplus (the trapezium P_0 P_1 E_1 E_0) and increase in the port tariff revenue net of the marginal capital and operation costs from the expansion. The increase in consumer surplus can be estimated by means of the transport cost regressions undertaken above. The policy assumptions on the capacity expansion of the ports will imply the target point change of our port congestion index. Multiplying these point changes with the estimated coefficient of the index, around 0.0737, gives the estimates of percent changes of transport costs. As actual transport costs are largely unobservable, except for U.S. and Japan, the amount of gain in consumer

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[29] Another important question, beyond the scope of this analysis here is how to measure to what extent port infrastructure is a bottleneck or major constraint in a specific country. This question would require additional data and modifications to the analytical approach taken here.

surplus can only be measured in terms of these percentage changes in transport costs[30]. This correspond to a rectangular, instead of trapezium P_0 P_1 E_1 E_0, ignoring the small remaining triangle, giving an acceptable approximation. One should note that the consumer surplus in the framework, as well as the estimated gains in the consumer surplus, is affected by the costs caused by the congestion and port tariffs and other charges[31].

We face a challenge, due to the lack of systematic, consistent and comprehensive data, to estimate the increase in nominal revenues from port tariffs and other charges, and that of the capital costs for construction and upgrade of the port infrastructure to expand their capacity. This makes hard not only the policy simulation, but also the analysis of the cost structure of the port managements. The port authorities publish the port tariffs and other charges, but compiling their price indices will also be quite a challenge, due to finely itemized structure of the tariffs and charges. The authorities have issued *ad hoc* reports of the construction and maintenance costs, but the disclosure is much limited and not periodical at all.

Most of the port managements systems in the region are under corporate control but the port authorities take the various forms, including public or semi-public corporations, government owned enterprises, or joint-ventures. Their financial support comes from the issuance of bonds, private finance and government budget and lending, as well as the borrowing from international financial institutions. As for the market structure, the ports in the region have competed with each other, but their competition is regionally oligopolistic and by no means perfect. Overall, port authorities can enjoy some mark-ups of the prices on top of the marginal costs.

The financial management of port authorities in East Asian developing countries appears to perform very well, as evidenced by their aggressive expansion plans[32]. More than full cost recovery without government subsidy has appeared to prevail, and the increase in the revenue from the tariffs and charges fully or more than compensates the increase in the capital cost, caused by the construction. In our policy simulation, as an acceptable compromise, we assume

[30] However, we may obtain a rough idea of the consumer surplus, if we assume some plausible number as Ad valorem tax-equivalent transport costs on import prices, for example, at 30 percent.
[31] The shipping companies and forwarders are assumed to pass on all the costs in ports to the importers, which are recorded as the import charges in the official statistics.
[32] For example, an expansion plan of Honk Kong assumes the financial rate of return at as high as 14 percent.

the full cost recovery, implying that the port authorities take no excess profits from the investment on the port infrastructure. The net benefits of the port capacity expansion consist of only the increase in consumer surplus.

The assumption of exact full cost recovery may tend to lead an underestimate on the net benefits of the port improvement. This treatment would be balanced, however, as some concern has been voiced on the “overinvestment” in port infrastructure in the developing countries in East Asia for the future, such as China. In such concerns, the returns higher than those with full cost recovery would not continue to apply in the near future.

In order to give a general sense on the cost, we will also assess how large the capital costs of port expansion works are in terms of transport costs. In spite of the lack in data, some published reports and news give us an access to the port investment costs, and we may gain a rough idea of unit cost for expanding port capacity. This can be convertible to the transport costs, enable to compare the benefits with costs.

The Baseline Policy Scenario and Its Impacts on Transport Cost

We set a policy scenario on the expansion of the capacity of the major ports in the developing countries in East Asia. Table 7 below shows the impacts on the transport costs for the import of the countries under our baseline scenario. Our policy scenario is such that the port capacity in the developing countries in East Asia is invariably expanded by 10 percent.

Table 7: Impacts of Port Capacity Expansion on Transport Cost: Baseline Scenario

	Transport Cost of Imports (%)		
	Total	*Unloading*	*Loading*
Indonesia	-1.38	-0.76	-0.62
Malaysia	-1.32	-0.82	-0.50
Philippines	-2.47	-2.07	-0.41
Singapore	-1.76	-1.39	-0.37
Thailand	-1.37	-1.05	-0.32
China	-1.40	-1.20	-0.20
Japan	-0.42	–	-0.42
Korea	-0.24	–	-0.24
Hong Kong	-2.66	-1.91	-0.75
Taiwan	-1.27	-0.97	-0.29
Viet Nam	-1.65	-0.82	-0.82

(Source) Authors'estimate. The Baseline Scenario assumes the expansion of port capacity by 10 percent for the developing economies in East Asia.

Under the scenario, highly congested ports, such as those in Philippines, Honk Kong and Singapore, will find considerable improvement. The third and fourth columns show the simulated impacts on the transport costs on imports of the economies in the table. This estimate assumes that all the economies take transport cost function invariably taking the following form:

$$\ln TradeCost_{ij} = \ln(Freight_{ij} + Insurance_{ij} + others_{ij}) = f(...) + port\cos t_i + port\cos t_i$$
$$= g(...) + \gamma_1 PIndex_i + \gamma_2 PIndex_j \qquad \text{….. (4)}$$

Where f(…) and g(…) represent functions, taking the explanatory variables in regression (2) and (3), except for the *PIndex*. Subscripts *i* and *j* denote the exporting and importing countries.

The specification (4) generalizes the stipulation of (2) and (3) by including the costs incurred to the traders both in exporting and importing ports (i.e. variables $portcost_i$ and $portcost_j$, or $PIndex_i$ and $PIndex_j$, more specifically). We have added somewhat bold assumption that γ_1 and γ_2 take the same value that is equal to what is estimated in regression (2) and (3). The numbers in the second column represent the impacts on the transport costs for import of the countries in terms of the percentage change, consisting of the cost-reducing effects in both from (i) their own ports for unloading (the third column) and (ii) the ports of their trade partners for loading (forth column).

The estimated reduction in the transport costs of imports ranges from one-half to nearly 3 percent. The impact is significant. For example, one may recall that the leaders of Asia-Pacific Economic Cooperation in 2001 committed to implementing the APEC Trade Facilitation Principles (Shanghai Accord) with a view to reducing trade transaction cost by 5 percent by 2006[33]. The transaction cost defined in the Accord covers the wider scope of trade cost than the narrowly-defined international transport cost, but the latter represents a significant proportion of the former, around one-third[34]. The estimated impacts of the Baseline Scenario would enable several APEC members to meet even one sixth of the target of the Accord .

Moreover, if we assume that the international transport costs are 20 percent *ad valorem* tax-equivalent on import prices for all the countries at the modest side, the cost reduction effect is from 0.3 to 0.5 percent of the import prices among the developing economies in East Asia. This cost reduction effect is equivalent to the across-the-board tariff reduction, covering all the imported commodities. As the Baseline Scenario can be realistically achieved, port investment provides an effective tool for trade facilitation.

Costs of Investment in Port Infrastructure: A General Overview

Anecdotal evidence provides a general sense of how large the costs of investment and operation of port infrastructure may be in the region. One feasibility study, for example, on the dredging at Korea's Busan port verified the need for deepening at selected berths at the container terminals of Shinsundae, Gamman, Shingamman and Jasungdae. The cost for this project amounted to US$31 million. The report also suggested that the cost would be recovered only if the port would handle 72,000 TEU more. As this figure implies the minimum amount of the port capacity, the expansion of the port by one TEU may cost around $43 per year, if the average financial costs of

[33] The Accord include a text as follows: Leaders instruct Ministers to identity, by Ministerial Meeting in 2002, concrete actions and measures to implement the APEC Trade Facilitation Principles by 2006 in close partnership with the private sector. The objective is to realize a significant reduction in the transaction costs by 5% across the APEC region over the next 5 years.

[34] Anderson and van Wincoop (2004) illustrates that the representative international trade costs for industrialized countries is 74 percent in terms of *Ad Valorem* tax equivalent. This number breaks down, as 21 percent of transportation costs, and 44 percent of border-related trade barriers. The transaction costs defined in the Accord may cover the first break-down and some of the second and the third. With this, the transportation costs are around one-third of the international transaction costs in total.

capital or simply interest/discount rates are 10 percent. This example does not cover the construction cost, but dredging costs considerably.

Another example is a long-term feasibility study report on Hong Kong ports. This report suggests that the average financial incremental cost for a new port construction project is HK$576 per TEU. This implies that capital -- and presumably operation cost -- of one TEU expansion is $74[35]. Another example of costs in developing countries focused on Shanghai ports in a newsletter report that the construction of Mingdong berths, 1,000 meters, in 2004 cost RMB 4 billion. The normal capacity of the berths in all is estimated about 975,000 TEU. One TEU costs $51, applying 10 percent for the discount rate and exchange rates of 7.97 RMB yuan per dollar.

From these examples, the annual cost for the expansion of the port capacity by one TEU would be around $40 to $80. If the port infrastructure projects are viable, the amounts are recovered with the increase in port tariffs and various charges by the port authorities. The rough estimate also gives us a general sense of the costs and benefits of the port development. Our baseline of the port expansion in East Asia totals about 36 million TEU[36], costing some $1.4 to 2.9 billion per year. In contrast, if the transport cost on average in the region is assumes to be 20 percent, the consumer surplus of the expansion of port capacity would amount to $8 billion per year. This would well justify the port infrastructure projects in the developing economies in East Asia economically, as well as financially. An interesting question in future work is how to measure to rate of return of investment in port infrastructure with empirical data to explore to what extent benefit of investment is captured by the country itself and by its trade partners (within and outside East Asia).

[35] The financial internal rate of return of this project is as high as 18 percent, demonstrating the port projects are very viable.

[36] We assume that (i) average utilization rate of the container terminals is three quarter of the full capacity, (ii) each container ship stays 2 days on average, including waiting time for disembarkation, loading and unloading time, and (iii) the vessels carry the container cargo with three quarter of their full capacity. Then, about 200 times of estimated port capacity can be used for a year.

Economic Crisis and Viability of Port Projects in East Asia

The port projects in the developing economies in East Asia were economically viable until the year 2006. However, it should be reminded that benefits of expansion depend on the growth of trade, lagged construction, and resulting congestion in the ports. It is not clear that the economic viability of expansion remains in a period of economic crisis and declining trade in the region. In this section, we examine port utilization in ASEAN5 and China in 2008 and thereafter during conditions of economic crisis.

Our basic assumptions are: (i) the throughput of container terminals is proportional to trade in the real terms; (ii) port congestion is measured by the turnover ratio[37], which were 82 times and 90 times, for ASEAN5 and China in 2006, respectively; and (iii) the planned rates of the expansion of ports are 18 percent in China and 2 percent in ASEAN5 per annum until 2008, i.e. the actual growth rates from 2001 to 2006. The turnover ratio in Singapore, Hong Kong and Shanghai, the most congested ports in the region, were 103, 177 and 142 in 2006, Extrapolating the provisional growth rates of real trade until 2008, the turnover ratios in ASEAN5 and China would be about 91 times and 80 times, respectively. From the data used in our regression, the sample average and standard deviation of the turnover ratio are 79 and 38. With the lower confidence boundary of one-half sigma, the effect of port congestion may emerge even at the level as low as 60 times. We may also be reminded that the perception of the congestion appeared even at the level of 80 times

In 2009, real trade for ASEAN5 and China is expected to decline. While reliable estimates have not published yet, most pessimistic figures of real trade growth of ASEAN5 and China in 2009 is about a 10 percent decline in trade[38]. With our assumptions, the turnover ratio would be 72 to 82 times, if there is no new investment in the sector. While these ratios are considerably low, compared with the past performance, congestion in East Asian ports may still remain. As a modest implication, investment in port infrastructure may be still economically sound and effective in reducing transport costs. Port capacity investments are also, our analysis suggests,

[37] Defined as the port throughput divided by the estimated port capacity, meaning the required turnover for the ports to process all the throughputs.
[38] From the economic forecasts of the governments of the United States and Japan.

viable long-term investments as global economic conditions Improve and trade recovers over time. Moreover, expansion in intra-regional trade will likely be a key factor in assisting in economic recovery over time.

5. Conclusion and Implications

Major Findings

The analysis in this paper suggests the following conclusions. First, port congestion for trading partners in East Asia has significantly increased transport costs for imports from both the United States and Japan. An increase in exports played an important role for these economies to achieve post-crisis recovery in the 1990s, however, infrastructure bottlenecks posed a serious obstacle to recovery. Looking beyond the crisis of 2008, port capacity in the region will still be a barrier to trade in 2009. One would expect that recovery of trade over time will continue to present problems related to shortages in port capacity.

Second, the expansion of port capacity under our baseline scenario, which is rather modest, to expand physical port capacity by 10 percent suggests that transport costs in East Asia could decline by one-half to 3 percent. If transport costs constitute about 20 percent *ad valorem* tax-equivalent on the import price, the effect is about a 0.3 to 0.5 percent across-the-board cut in tariffs. As this is a recovery of pure loss and technological progress, the welfare gains could be substantial. Third, port authorities in the region could achieve full cost recovery, evidenced by their aggressive investment to expand capacity. Although based on anecdotal evidence, trade cost reductions could far outweigh the cost for physical expansion of the ports in the developing economies in the region.

Implications

We may draw four implications from the analysis. First, port infrastructure improvement could provide a very good opportunity for trade liberalization and facilitation for the region. In particular, the economies of Singapore and Hong Kong, where tariff rates are virtually zero, will be able to proceed with further trade liberalization and facilitation by expanding and improving their port facilities. Second, as port infrastructure projects are economically viable long-term investments, private-sector participation in the projects could be a major vehicle for finance, such as through private-public partnerships.

Third, active investment in the region could bolster economic recovery over time in East Asia. Since investment in port infrastructure can be justified and viable to reduce bottlenecks even in the period of recession, this will provide a useful tool for governments in the developing economies in both macroeconomic demand and supply terms. Forth, the nature of the effect of port infrastructure improvements is equivalent to across-the-board uniform tariff reductions. As such, importing countries would suffer less from trade diversion and port investment may face less serious resistance in a public policy context. Finally, future research to extend our analysis on economic welfare and growth (through trade) in different countries is also an important empirical and policy question.

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Appendix: Construction of Port Congestion Index

The index to compile is aimed to examining the effect of the physical investment of the ocean container-specialized port facilities on the trade costs. As stipulated in the fourth section in the main text, the capacity of the port directly affects the costs for its services in two aspects: the first is through the port tariffs and other charges for the unloading and loading services, and the second is the time costs due to the congestion. The expansion of the port capacity is accompanied by higher tariffs and charges, but lower degrees of congestion and waiting time for the movement of goods.

We have compiled an index of port turnover , defined as the sum of the loaded and unloaded containers in TEU (Twenty-foot Equivalent Unit) at the major container ports in the country *i* in the year *t*, divided by the sum of the estimated capacity of the major container ports in the country *i* in the year *t*. Table below summarizes the ports referred to in the compilation of the index, together with the actual throughput and estimated port capacity of each port, and estimated port congestion turnover index for the country/economy. The numerator of the congestion index reflects the actual throughput of the major ports reported in the issues of *Containerization Yearbook*. The same reference is used to estimate the capacity.

The estimate of the port capacity builds on only the physical magnitude. We put the following assumption on the full physical capacity of the port, based on the numbers and depths of the berths: The berths with 14 meters or deeper in depth can accommodate the vessel with 6000 TEU. The vessels use up 250 meters of the berth. The births with 13 meters in depth can accommodate the vessels with 3250 TEU, using up 200 meters of the berth. Those with 12 meters in depth, the vessels with 1750 TEU, using up 150 meters of berth. Those with less than 10 meters in depth, 500 TEU, using 100 meters and less of berth. Combination of various sizes of vessels are applied to maximize the estimated capacity the port can accommodate at once.

Table: Throughput, Port Capacity and Congestion Index of Major Ports in East Asia

Country/Economy	Port Name	Throughput in 2006 (A)	Port Capacity in 2006 (B)	Turenover in 2006 (=A/B)	Turenover in 2003 (=A/B)
Indonesia	Tanjong Priok	3280	56	56.7	67.2
	Tangjong Perak	1798	34		
Malaysia	Port Klang	5946	124	61.2	60.6
	Tangjong Pelepas	4480	47		
Philippines	Manila	2853	19	154.2	137.9
Singapore	Singapore	22780	220	103.4	83.9
Thlailand	Bangkok	1535	18	78.3	67.5
	Leamchabang	3984	53		
China	Dallian	3120	54	89.5	105.1
	Guangzhou	6403	114		
	Ningbo	6827	56		
	Qingdao	7608	90		
	Shanghai	21280	121		
	Shenzhen	17881	312		
	Tianjin	5788	51		
	Xiamen	3867	17		
Japan	Chiba	48	2	32.8	31.7
	Hakata	705	18		
	Hiroshima	205	8		
	Kawasaki	46	9		
	Kitakyushu	511	21		
	Kobe	2390	103		
	Nagoya	2632	62		
	Osaka	2237	74		
	Shimizu	564	26		
	Tokyo	3498	68		
	Yokohama	2793	87		
Korea	Busan	11933	203	57.3	81.9
	Inchon	1215	27		
Hong Kong	Hong Kong	22893	161	142.6	174.0
Taiwan	Kaoshiung	9569	132	61.5	57.7
	Keelung	2113	34		
	Taichung	1204	44		
Viet Nam	Danang	36	3	72.7	234.4
	Haiphong	614	3		
	Hochiminh	2023	32		

(Note) Throughput and Capacity is in 1,000 TEU in a year.

The index is in terms of ratio The higher the ratio is, the more the costs of congestion are, and the more changes to force the traders the waste of time. The index builds on the major ports in East

Asia, which conduct most of the international trade. In this sense, this index should not regarded as proxy.