Investing in Port Infrastructure to Lower Trade Costs in East Asia

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We examine how port infrastructure affects trade and role of transport costs in driving exports and imports for East Asia. Existing studies use survey indexes to explain transport costs. These do not link investment in port infrastructure to transport costs. We include in our estimates a variable to represent the congestion of the ports to explain the transport costs. We find that the port congestion has significantly increased the transport costs from East Asia to the United States. Our analysis suggests that increase in port capacity by 10 percent could cut transport cost in East Asia by up to three percent. This translates into a 0.3 to 0.5 percent across-the-board tariff cut.

Keywords: International Trade, Trade Costs, East Asia, ASEAN, China, Trade Facilitation, Infrastructure, Gravity Model

JEL Classification: F13, F15
동아시아에서 운송비 절감을 위한 항만 인프라 투자에 관한 분석

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본 연구는 항만 인프라가 무역에 미치는 영향과 동아시아 수출입에 대한 수송비용 역할에 관해 고찰하고 있다. 기존 연구는 수송비용을 통계적으로 설명하기 위해 설문조사에 따른 지수를 사용해 왔지만, 이것으로는 항만 인프라에 대한 투자와 수송비용의 관계를 추정하는 데 분명하지 않다. 이 때문에 본 연구는 항만의 혼잡도를 나타내는 변수를 독자적으로 추계하고, 이를 수송비용의 설명변수로 사용하였다. 그 결과, 동아시아에서 항만 혼잡도가 미국에 대한 수송비용을 통계적으로 유의미하게 증가시키는 것으로 판명되었다. 본 연구의 분석에 따르면, 항만의 물리적 처리능력을 10% 증가시키면, 동아시아에서 수송비용을 3%까지 감소시키는 것이 가능하다. 이를 관세로 환산하면 0.3~0.5% 정도의 식감에 해당한다.

핵심용어: 국제무역, 교역비용, 동아시아, 아세안, 중국, 무역원활화, 인프라, 중력모형
JEL 분류: F13, F15
I. Introduction

This paper empirically examines how investment in port facilities affected the trade costs in East Asia. 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 stat, resulting in the higher trade costs in the region. The scope of the study includes the benefits of the construction of port infrastructure to address traffic congestion in East Asia.

1. 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 the 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 transports between China and some ASEAN5 members contribute to their trade, but they are limited, because major part of their international trade takes place between the industrial center of China, i.e. her coastal provinces, and ASEAN5. Air transport is rapidly increasing and taking substantial shares especially in trade value. However, the dominant value of trade of the developing countries still relies on sea transport. For example, the share of air over the total imports of Japan from China and ASEAN5 countries were only 22 percent and 26 percent, respectively, in value in 2006.

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. Shortage in port capacity and
quality in the developing countries in this region, however, has risen over the past decade.

2. 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](image)

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 the table in Appendix 1 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.

Source: Authors’ estimates, *Containerization International Yearbook, Shipping Statistics Yearbook*.

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 ports capacity in Japan.

Ports with sufficient capacity, efficient facilities with high technology, and good management contribute to lower costs for international transport and trade costs in total. 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. In contrast with the existing studies, which invariably estimated the effects of the port-related policies by using survey indexes on the port efficiency, our study has developed an index, explicitly measuring the congestion of the ports in East Asia. This enables us to estimate directly the effects of the investment in port infrastructure.
II. 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,1) including transport costs, policy barriers, information costs, contract enforcement costs, currency costs, and legal and regulatory costs2) (Anderson and van Wincoop 2004). The same reference speculates that poor countries have higher trade costs, that may be likely because of their higher policy barriers and inefficiencies.

Transport costs often have significant shares in the trade costs. According to the reference, nearly 30 percent of trade costs can be attributed to transport 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. The time required for the port operations has been found to affect significantly the trade/transport costs. This section surveys the existing literatures on the infrastructure and transport costs, focusing on the empirical findings on the ocean ports, in particular.

1. 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

1) Defined as international trade costs divided by the value of the imported goods in the country of origin.
2) 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 (2007), and Abe and Wilson (2008).
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 to estimate the effect of the unobservable trade costs, represented by these factors, on the trade. However, to what degree these variables affect trade cost itself and to what degree the trade cost affects the 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 sum 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 the United States and New Zealand officially publish shipping/transport cost data based on the declarations from the importers for the taxation purpose.3)

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. Lima 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

3) Other few countries appear to have transport data in cross-section (Hummels and Lugovsky 2006).
2. 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, including road, rail, and telephone. According to their findings, sea transport is much cheaper than land transport. In contrast, explicit measures of port infrastructure should be necessary in our study on East Asia where the dominant proportion of the trade is made between sea ports.

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 ports4). 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

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4) 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.
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.\(^5\)

The authors test four different indicators as the proxies of the port efficiency, including: (i) country specific port efficiency index from *The Global Competitiveness Report*\(^6\); (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 to 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

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5) 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.

6) *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.
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.

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. 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 hands, 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 give good reference with rich information on the cost efficiency of the ports in a wider sense.

7) For example, Singapore continues to take the top in the ranking of port infrastructure quality index in The Global Competitiveness Report.
3. Published Data on Ad valorem Transport Costs in East Asia

As noted above, U.S. official statistics report import charges aggregated at the detailed HS commodity classification. Table 1 summarizes the *ad valorem* ratio of import charges over the amount of imports from selected East Asian countries in the United States, averaged for 1996-2000 and 2001-2006. Note that the data cover all the modals of the imports, including air, ocean and land shipments.

|                  | 1996-2000 | 2001-2006 |
|------------------|-----------|-----------|
| Indonesia        | 7.12      | 7.68      |
| Malaysia         | 2.93      | 2.93      |
| Philippines      | 3.57      | 4.37      |
| Singapore        | 1.68      | 1.80      |
| Thailand         | 4.81      | 5.82      |
| Viet Nam         | 7.33      | 8.28      |
| China            | 6.46      | 6.72      |
| Korea            | 3.36      | 3.79      |
| Hong Kong        | 4.08      | 4.69      |
| Taiwan           | 3.92      | 4.32      |
| Canada           | 1.79      | 1.49      |
| Australia        | 6.13      | 4.78      |
| New Zealand      | 9.36      | 7.36      |
| Japan            | 2.53      | 2.67      |

Note: 1) The rates are defined as: (Import Charge)/(Import in FOB and Custom Value)*100.
Source: US: Department of Commerce.

Table 1 suggests that *Ad valorem* transport costs are generally higher than nominal tariff rates in the United States. The simple average rate of nominal tariff of the United States is only 3.5 percent in 2006, according to 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.

III. 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. The existing studies used survey indexes to explain transport costs, failing to link the physical port investment to transport costs. Instead, we have estimated an index of physical capacity and congestion of ports, and include it in the regression as an explanatory variable in the transport cost model to measure the effects. This enables us to directly assess the infrastructure policies by domestic governments and ODAs. This section discusses the specification of the regression and the infrastructure indicators with some theoretical consideration, and examines the results.

1. 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 indexes of Blonigen and Wilson, covering transport costs, are estimated from the import charge statistics of the United States. If ports are congested not only do freight and insurance costs increase, but also

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8) 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.
miscellaneous costs to traders, such as idle time at ports\textsuperscript{9),} around the ports may further accumulate. Our empirical interest exists in the effect of expansion of physical port capacity which would reduce such costs.

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

The downward-sloping demand curve in the figure represents the demand for port services,\textsuperscript{10}) 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

\textsuperscript{9) See Simeon et al. (2006).}

\textsuperscript{10) 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.}
of the congestion/inefficiency in the port (P – PT). At the time 0, the equilibrium in the market is at E₀. With the lower full capacity of the port at F₀ before expansion of port facility, the congestion cost is larger (P₀ – PT₀), in spite of the smaller port tariff at PT₀. 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 F₁. The port tariff (horizontal) part of the supply curve may shift upward to recover the construction costs¹¹, but the upward-sloping part of the supply curve, representing congestion, shifts rightward and downward. At the new equilibrium E₁, 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.

2. Specifications and Data of the Trade Cost Regression

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 Clark, 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 the trade rapidly increased after the Economic Crisis around the years 1998 to 2000 and the congestion in the ports materialized.

\[
\ln \left( \frac{TC_{ikt}}{Wgt_{ikt}} \right) = \alpha_0 + \sum_k \alpha_{1k} + \sum_i \alpha_{2i} + \alpha_3 \ln(\text{dist}_{it}) + \alpha_4 \ln \left( \frac{\text{Value}_{ikt}}{Wgt_{ikt}} \right) + \alpha_5 \ln(Wgt_{ikt}) + \alpha_6 \text{Cnt}_{it} + \alpha_7 \text{PIndex}_{it} + \epsilon_{it} \tag{1}
\]

where: \( TC_{ikt} \): the amount of the import charge for the imports of the United

¹¹ The port authority may take rent, in addition to the capital cost, due to the superior services created from the investment.
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. 200412)). The distance estimated for 1998 is applied to the observations for 2001 and 2002, and that for 2003 is applied to those thereafter. The distance variable here may better measure the cost of ocean transportation, because the shift of the relative usage of importing ports in the U.S. does affect the average distance between the U.S. and counterpart countries, which are time-variant. Clark, Dollar and Micco (2004) and other reference used simple distance, but their regressions were on the port-to-port trade costs and need not deal with the shift of relative usage of ports in the country.

$Wgt_{ikt}$: 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 $t$.

$PIndex_{it}$: 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 $t$.13) 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.

12) Unpublished manuscript. The authors appreciate the kind provision of the data in the electronic form from Dr. Shibasaki.
13) See Appendix 1 for the detailed methodology of the estimation of the port capacities.
(GCR) and water transportation index in *The World Competitiveness Yearbook* of IMD (*WCY*).

\(\alpha_{1k}\): 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, the 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.

Ordinary least square method with fixed effect panel estimate is adopted for the regression. 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. The descriptive statistics for the variables in the regression are summarized in Appendix 2.

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

Table 2 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 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.

The first specification that uses our port congestion index results in the values of parameters on distance, value/weight, weight, and containerization ratio, which are generally within the comparable range to the existing empirical studies. The distance variable has an elasticity, with a value of positive but less than one, as a standard gravity equation expects. The estimated elasticity of the value/weight variable has a positive value, as luxurious commodities require more transport costs. The weight variable has a negative elasticity, as bulky

Table 2. Determinants of Trade Cost per Weight from Asia–Pacific Countries to the U.S.

| dependent variable: import charge / weight | (1) | (2) | (3) |
|-------------------------------------------|-----|-----|-----|
| at 6-digits commodity level (log)         |-----|-----|-----|
| 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 |

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.

Source: Authors’ estimates, using U.S.A. Merchandise Imports DVDs.
commodities tend to be transported cheaply.

Our port congestion index takes a significantly positive coefficient. This is the expected result by our partial equilibrium framework, illustrated in Figure 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.\(^{14}\)

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.

4. Comparison and Correlations between the Indexes on Ports

14) We have tested the fixed and random effects methods by adding to the regression \(i\) times \(k\) dyad dummies to control the pair relation between the exporting country and commodity. A robust result has emerged, both from the fixed and random effects, with the statistically significant estimates of coefficients of the port congestion index at around 0.05 to 0.06. This result would support the credibility of the significance of the port congestion index.
The three indicators on ports used above should reflect information overlapping each other. Table 3 shows the correlations between the three indicators and the port efficiency measures by Blonigen and Wilson (2008)\(^\text{15}\) from 2001 to 2006.

Table 3. Correlations between the Indexes on Ports

|                  | Port Congestion | Port Infrastructure (GCR) | Sea Transportation (WCY) | Port Efficiency (BW) |
|------------------|-----------------|---------------------------|--------------------------|----------------------|
| 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 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

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\(^{15}\) 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 3.
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 bring about the fall in the port efficiency measurement by 1.3 percent. Because the port 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.

IV. Benefits of Port Infrastructure Improvement in East Asia

1. What are the benefits from the 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.

The partial equilibrium framework illustrated in Figure 2 above helps consider what happens to the welfare of the port users. In the diagram, the increase in welfare to the users, i.e. the consumer surplus, is brought about by the decline of the port-related total transport cost from \( P_0 \) to \( P_1 \) and the benefit from the reduction of congestion. 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.

The increase in consumer surplus can be directly 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, according to the U.S. regression, gives the estimates of percent changes of transport costs. As actual transport costs are largely unobservable, except for U.S., the amount of gain in consumer surplus can only be measured in terms of these percentage changes in transport costs\textsuperscript{16). 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.\textsuperscript{17)}

2. 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 4 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.

\textsuperscript{16) 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.

\textsuperscript{17) 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.}
Table 4. Impacts of Port Capacity Expansion on Transport Cost:
Baseline Scenario

| Country    | 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 the Philippines, Hong 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:

\[
\ln TradeCost_{ij} = \ln (Freight_{ij} + Insurance_{ij} + others_{ij}) = f(...)+ port cost_i + port cost_j
= g(...)+ \gamma_i PIndex_i + \gamma_j PIndex_j
\]

(2)

Where \( f(\cdots) \) and \( g(\cdots) \) represent functions, taking the explanatory variables in regression (1), except for the \( PIndex \). Subscripts \( i \) and \( j \) denote the exporting and importing countries.

The specification (2) generalizes the stipulation of (1) by including the costs incurred to the traders both in exporting and importing ports (i.e. variables
Investing in Port Infrastructure to Lower Trade Costs in East Asia

portcost_i and portcost_j, or PIndex_i and PIndex_j, more specifically). We have added somewhat bold assumption that \( \gamma_1 \) and \( \gamma_2 \) take the same value that is equal to what is estimated in regression (1). 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 three 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 five percent by 2006\(^{18}\). 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\(^{19}\). 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, the cost reduction effect is from 0.3 to 0.5 percent of the import prices among the developing economies in East Asia. The assumption of 20 percent above is at the modest side, as the transport cost for the U.S. imports are estimated to be

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\(^{18}\) 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.

\(^{19}\) 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.
21 percent, according to Anderson and van Wincoop (2004) and the trade cost for the developing countries is certainly higher. This cost reduction effect in the Ad valorem terms is equivalent to the across-the-board tariff reduction of the same percentage, covering all the imported commodities. As the Baseline Scenario can be realistically achieved, port investment provides an effective tool for trade facilitation.

V. Implications

The analysis in this paper suggests the following conclusions. First, port congestion in East Asian countries has significantly increased their transport costs. An increase in exports played an important role for these economies to achieve the post-crisis recovery in the 1990s, however infrastructure bottlenecks must have posed a serious obstacle to recovery in 2000s.

Second, the expansion of the port capacity under our baseline scenario, which is rather modest, to expand the port physical capacity by 10 percent suggests that transport costs in East Asia could decline by one-half to three 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.

We may draw two implications from the analysis. First, port infrastructure improvement could provide 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, 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.
Appendix 1: Construction of Port Congestion Index

The index to compile is aimed at examining the effect of the physical investment in the ocean container-specialized port facilities on the trade costs. As stipulated in the fourth section of 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 congestion. The expansion of the port capacity is accompanied by higher tariffs and charges, but lower degrees of congestion and waiting times 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. The capacity is in terms of TEU units that can be physically accommodated at a port at any one point in time. The number is determined by the number and length of berth and their depth. 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. A vessel uses 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
Table A-1: 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                     |
| Thailand        | Bangkok         | 1535                   | 18                        | 78.3                     | 67.5                     |
|                 | Laemchabang     | 3964                   | 53                        |                          |                          |
| China           | Dalian          | 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                     |
|                 | Incheon         | 1215                   | 27                        |                          |                          |
| Hong Kong       | Hong Kong       | 22893                  | 161                       | 142.6                    | 174.0                    |
| Taiwan          | Kaohsiung        | 9569                   | 132                       | 61.5                     | 57.7                     |
|                 | Keelang          | 2113                   | 34                        |                          |                          |
|                 | Taichung        | 1204                   | 44                        |                          |                          |
| Viet Nam        | Danang          | 36                     | 3                         | 72.7                     | 234.4                    |
|                 | Haiphong        | 614                    | 3                         |                          |                          |
|                 | Hochimin        | 2023                   | 32                        |                          |                          |

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

applied to maximize the estimated capacity the port can accommodate at once.

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 be regarded as proxy.
Appendix 2: Summary Statistics in the Regressions

Table A–2: Summary Descriptive Statistics in the Regression

| Variables                                | # of Obs. | Mean | Std. Dev. | Min.  | Max.  |
|------------------------------------------|-----------|------|-----------|-------|-------|
| Transport costs per weight (in logarithm)| 151,249   | -1.19| 1.13      | -17.27| 11.18 |
| Distance (in logarithm)                  | 151,412   | 8.88 | 0.11      | 8.70  | 9.08  |
| Value per weight (in logarithm)          | 151,306   | 1.79 | 1.3       | -6.97 | 14.01 |
| Port congestion index                    | 151,336   | 152.2| 76.1      | 55.7  | 468.8 |
| Port Infrastructure Quality (GCR)        | 151,336   | 4.91 | 1.23      | 2.20  | 6.90  |
| Water Transportation Quality (WCY)       | 145,709   | 6.48 | 1.49      | 3.14  | 9.47  |
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아베 카즈토모(阿部一知)

현재 도쿄전기대학 교수로 재직 중이며, 하와이대학에서 박사학위를 취득하였다. 1980년부터 20년 이상 일본정부를 위해 일하면서 경제 조사연구・경제자문 업무에 종사하였 다. 주요 경력은 아시아개발은행 이코노미스트(1993~96년), APEC 경제위원회 의장 보좌 (1999년), 세계은행 자문위원(2007~08년) 등이며, 연구 분야는 국제무역과 경제개발, 계량 모델, 동아시아의 거시경제 문제 등이다.

존 윌슨(John S. Wilson)

현재 세계은행 선임 이코노미스트(연구개발그룹)로 재직 중이다. 콜럼비아대학에서 학 위를 취득하였으며, 주요 수행업무는 무역비용, 정책 투명성과 경제개발에 관한 조사연구 의 관리 업무이다. 현재 세계은행에서 총 13억 달러 이상 규모의 프로젝트를 실시하고 있 으며, 표준 및 무역개발기금 설립을 주도하였다. 주요 경력은 미국 정보기술산업연구소의 기술정책 담당 부사장, 국제무역연구소 책임연구원, 미국 과학기술 아카데미・국립연구위 원회의 상임연구원 등이다.