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The Impact of Infrastructure on Trade and Economic Growth in Selected Economies in Asia

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Abstract

Infrastructure plays a key role in facilitating trade, especially since recent trade liberalization in Asia has resulted in significant tariff reductions. This study quantifies the impacts of both hard and soft infrastructure on trade volume for exporters and importers in the region as well as on various economic growth indicators.

Results demonstrate that improvements in transport infrastructure (i.e., the road density network, air transport, railways, ports, and logistics) have resulted in increased trade flows. Information and communications technology (ICT) infrastructure has also enhanced trade, as the numbers of telephone lines, mobile phones, broadband access, internet users, and secure internet servers are found to have positive trade effects for both exporters and importers in Asia. Thus, although more attention has traditionally been given to hard infrastructure, the impact of soft infrastructure on trade flows must also be more thoroughly examined.

JEL Classification: O18, O53, R53

Contents

1. BACKGROUND

Many economies in Asia have exhibited a bandwagon effect by signing trade integration agreements and lowering tariff barriers to increase trade. For example, members of the Association of Southeast Asian Nations (ASEAN) now enjoy tariff import rates as low as 0%, and ASEAN has also recently expanded to include the People’s Republic of China (PRC), India, Japan, and Republic of Korea. Extensive evidence has also shown that improving international transport fosters international trade, such as through tariff liberalization (Baier and Bergstrand 2007; Andriamananjara et al. 2004). Facilitating trade is necessary to minimize the cost of trade and to provide access to markets.

In Asia, the trade pattern has also recently shifted from finished products to intermediate and processing products. Economies that specialize in different tasks have added value to parts and components, which are imported for processing and assembly into semi-finished or finished products and then re-exported to the global supply chain before reaching end-users.

Table 1 shows the performance of exports and imports in Asia. The PRC, India, Singapore, Thailand, and Viet Nam increased their export–gross domestic product (GDP) ratio from 16.0% to 60.0% between 2000 and 2012. The agricultural export–export ratio in Viet Nam further increased by 42.0% (from 1.9% in 2000 to 2.7% in 2012), followed by Thailand (49.0%), Philippines (52.0%), India (55.0%), and Indonesia (63.0%). Intra-Asian trade also increased by more 200% from 2003 to 2013.

With such increased trade, trade cost has become a major concern. According to Anderson and Van Wincoop (2003), trade cost was estimated at 170% (in terms of ad-valorem equivalent) for industrialized countries. The major categories of trade cost were transport (21%), border-related trade barriers (44%), and retail and wholesale distribution (55%). However, trade cost is even larger in developing countries, many of which are found in Asia; thus, infrastructure is relevant to trade facilitation, particularly in minimizing trade cost and further enhancing competitiveness.

Infrastructure is vital to economic development, as it is key to achieving higher and stable economic growth. Although most economies in Asia have already developed their basic infrastructure, the focus of development is usually on the quantity rather than the quality. According to World Economic Forum (2014), well-developed infrastructure not only reduces the distance between regions but also integrates national markets and connects them at low costs to other economies.

Table 1: Trade Performance in Asia, 2000 and 2012

	People's Republic of China	Hong Kong, China	Republic of Korea	India	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam	East Asia	OECD
2000												
Agricultural exports (% of exports)	1.1	0.4	1.0	1.3	3.6	2.6	0.6	0.5	3.3	1.9	1.7	1.9
Agricultural imports (% of imports)	4.8	1.2	3.2	3.5	7.2	1.3	1.4	0.4	3.0	2.9	4.2	2.0
Exports of goods and services (% of GDP)	20.7	141.8	35.0	12.8	41.0	119.8	51.4	189.2	66.8	50.0	31.2	22.6
Imports of goods and services (% of GDP)	18.7	137.4	32.9	13.7	30.5	100.6	53.4	176.9	58.1	53.3	27.6	23.2
Manufacturing exports (% of exports)	88.2	95.3	90.7	77.8	57.1	80.4	91.7	85.6	75.4	42.7	82.4	78.5
Manufacturing imports (% of imports)	75.1	90.5	62.2	46.7	60.9	84.8	78.0	81.8	76.7	72.7	75.3	73.4
2012												
Agricultural exports (% of exports)	0.5	3.4	1.1	2.0	5.9	2.4	0.8	0.3	4.9	2.7	1.6	1.6
Agricultural imports (% of imports)	3.9	0.6	1.6	1.8	2.6	2.5	0.6	0.4	1.8	3.3	3.2	1.3
Exports of goods and services (% of GDP)	24.2	225.6	56.3	24.4	24.6	85.3	30.8	195.4	75.0	80.0	31.2	27.2
Imports of goods and services (% of GDP)	21.5	224.4	53.5	31.1	25.0	73.7	33.9	172.8	73.8	76.5	28.7	27.8
Manufacturing exports (% of exports)	93.9	68.6	85.1	64.8	36.2	61.7	82.6	69.8	73.8	69.4	82.6	71.4
Manufacturing imports (% of imports)	55.2	89.8	50.0	43.2	62.4	69.0	63.9	60.2	68.7	73.7	59.8	64.9

GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development.

Source: World Bank. World Development Indicators.

Trade facilitation is partially defined as the systematic rationalization of customs procedures and documents; it further encompasses all measures that affect the movement of goods between buyers and sellers along the entire international supply chain (ADB 2009, UNESCAP 2009). Trade facilitation embodies both hard and soft infrastructure (Portugal-Perez and Wilson 2012). Hard infrastructure, often referred to as physical infrastructure, refers to roads, airports, ports, and rail; indicators include quality and quantity. The information and communications technology (ICT) sector is also regarded as physical infrastructure, comprising indicators of the use, availability, absorption, and government prioritization of ICT.

Soft infrastructure refers to matters related to border and transport efficiency, and indicators measure the level of customs efficiency and domestic transport that is signified in the time, cost, and number of documents needed for export and import procedures. It also includes the business and regulatory environment, and indicators include regulations, transparency, irregular payments, favoritism, and measures to combat corruption.

This study examines if the type of infrastructure plays an important role in promoting trade and enhancing economic growth.[1] It seeks to identify the role of infrastructure in reducing trade costs, thus raising the trade volume and value. In addition, it aims to provide empirical evidence to identify the importance of infrastructure quality to growth enhancement.

The specific objectives of this study are to

(i) examine the impact of hard and soft infrastructure on exports,

(ii) investigate whether hard and soft infrastructure matter for manufacturing and agricultural exports, and

(iii) investigate the effects of quantity and quality of infrastructure on economic growth.

[1] Asian economies included in the sample are the People’s Republic of China; Hong Kong, China; India; Indonesia; Republic of Korea; Malaysia; Philippines; Singapore; Thailand; and Viet Nam.

2. INFRASTRUCTURE DEVELOPMENT IN ASIA

Table 2 shows the overall infrastructure performance in Asia, improvement (with 7 as the best performance), and rank from 2006 to 2013. There is still a huge gap in terms of index and rank, especially in Southeast Asia, with the exception of Singapore.

Table 2: Infrastructure Performance-Selected Economies in Asia, 2006, 2010, 2013

	2006		2010		2013	
	Value	**Rank**	**Value**	**Rank**	**Value**	**Rank**
People's Republic of China	3.73	52	4.31	46	4.46	48
Hong Kong, China	6.22	4	6.54	2	6.72	1
India	3.39	62	3.47	76	3.60	84
Indonesia	2.81	78	3.20	84	3.75	78
Republic of Korea	5.21	23	5.60	17	5.92	9
Malaysia	5.34	20	5.05	26	5.09	32
Philippines	2.64	88	2.91	98	3.19	98
Singapore	6.35	3	6.35	4	6.50	2
Thailand	4.68	29	4.57	40	4.62	46
Viet Nam	2.61	90	3.00	94	3.34	95
Low-income	1.59		2.00		2.32	
Lower middle-income	1.87		2.53		2.87	
Upper middle-income	2.54		2.93		3.53	
High-income: OECD	5.20		5.23		5.47	
High-income: Non-OECD	3.44		4.79		4.98	

OECD = Organisation for Economic Co-operation and Development.
Source: World Economic Forum. Global Competitiveness Index. http://www.weforum.org/reports

In terms of the quality of infrastructure index reported by the Global Competitiveness Index for 2013, Hong Kong, China and Singapore were among the best-performing economies in the world. The Republic of Korea was also in the top 20 due to its quality of roads, rail, and other transport infrastructure. However, the quality gap in the region is large when viewing the ranks of India, the Philippines, and Viet Nam.

In addition to physical infrastructure, ICT is vital to trade and economic growth. ICT costs have been decreasing in Asia due to investment in ICT infrastructure. Table 4 shows that Hong Kong, China and Singapore were in the top 30 economies in the world regarding ICT infrastructure, but India and Indonesia were underdeveloped, especially for broadband internet and percentage of individuals using the internet.

Table 3: Selected Quality of Infrastructure Indicators, 2013

Series	Attribute	People's Republic of China	Hong Kong, China	India	Indonesia	Republic of Korea	Malaysia	Philippines	Singapore	Thailand	Viet Nam
Quality of overall infrastructure, 1–7	Value	4.27	6.55	3.89	4.00	5.62	5.52	3.73	6.36	4.53	3.41
	Rank	74	2	85	82	23	25	98	5	61	110
Quality of roads, 1–7	Value	4.50	6.24	3.65	3.74	5.82	5.44	3.56	6.22	4.88	3.08
	Rank	54	5	84	78	15	23	87	7	42	102
Quality of rail infrastructure, 1–7	Value	4.70	6.45	4.76	3.53	5.68	4.78	2.06	5.64	2.55	2.97
	Rank	20	3	19	44	8	18	89	10	72	58
Quality of port infrastructure, 1–7	Value	4.48	6.59	4.19	3.88	5.53	5.42	3.35	6.75	4.50	3.68
	Rank	59	3	70	89	21	24	116	2	56	98
Quality of air transport infrastructure, 1–7	Value	4.54	6.74	4.76	4.51	5.75	5.77	3.54	6.75	5.53	4.04
	Rank	65	2	61	68	22	20	113	1	34	92
Transport infrastructure	Value	4.92	6.60	4.71	4.44	5.86	5.40	3.33	6.45	4.83	3.35
	Rank	26	2	34	40	9	15	84	3	30	81

Note: 1 represents the worst, while 7 is the best.
Source: World Economic Forum. Global Competitiveness Index. http://www.weforum.org/reports

Table 4: Information and Communication Technology in Asia, 2013

Series	Attribute	People's Republic of China	Hong Kong, China	India	Indonesia	Republic of Korea	Malaysia	Philippines	Singapore	Thailand	Viet Nam
Fixed telephone lines per 100 population	Value	20.6	60.6	2.5	15.5	61.9	15.7	4.1	37.8	9.1	11.4
	Rank	58	5	118	82	2	79	109	29	96	88
Mobile phone subscriptions per 100 population	Value	81.3	227.9	68.7	115.2	110.4	140.9	106.8	153.4	120.3	149.4
	Rank	116	1	123	62	70	27	81	18	49	21
Population using internet, %	Value	42	73	13	15	84	66	36	74	27	39
	Rank	78	33	120	113	15	39	87	29	97	83
Fixed broadband internet subscriptions per 100 population	Value	13.0	31.6	1.1	1.2	37.6	8.4	2.2	26.1	6.2	5.0
	Rank	49	15	106	105	5	66	97	20	75	79
International internet bandwidth, kilobytes per second per user	Value	4.165	1,239.000	5.200	17.200	26.000	16.400	14.300	391.100	25.000	13.500
	Rank	118	2	113	74	60	77	85	4	62	87
Mobile broadband subscriptions per 100 population	Value	17.24	73.48	4.90	31.86	106.04	13.52	3.82	123.29	0.14	18.99
	Rank	71	10	99	53	4	79	104	1	131	69
ICT use	Value	2.34	6.22	1.36	2.26	5.76	2.85	2.01	6.06	2.17	2.41
	Rank	79	8	124	84	16	71	93	11	89	78

ICT = information and communications technology.
Source: World Economic Forum. Global Competitiveness Index. http://www.weforum.org/reports

3. LITERATURE REVIEW

3.1 Infrastructure and Trade

One approach to measure the impact of trade facilitation on trade flows is the gravity model, which assesses the impact of trade facilitation reforms on bilateral trade flows. Substantial evidence links improvements in trade facilitation and trade flows. For example, in a study by Wilson, Mann, and Otsuki (2005) of 75 economies, it was noted that improved trade facilitation could increase trade by 10%. This study supported an earlier study by Wilson, Mann, and Otsuki (2003) on the Asia-Pacific, which demonstrated that improving trade facilitation increased intra-Asia-Pacific Economic Cooperation (APEC) trade by 21%. Moreover, Hertel and Mirza (2009) examined the impact of trade facilitation reforms in South Asia, finding that such reforms resulted in a 75% increase in intraregional trade and a 22% increase in trade with other regions. Shepherd and Wilson (2009) reported that trade in Southeast Asia increased by 7.5% thanks to trade facilitation reforms, such as increasing port quality.

Portugal-Perez and Wilson (2012) assessed the impact of four indicators related to trade facilitation—physical infrastructure, ICT, border and transport efficiency, and the business and regulatory environment—on the export performance of 101 developing economies. Unlike previous studies that used principal component analysis, this study used factor analysis to derive the aggregate indicator. Accordingly, physical infrastructure was found to have the greatest impact on exports. In addition, utilizing a gravity model approach, Hernandez and Taningco (2010) addressed behind-the-border measures that influenced bilateral trade flows in East Asia, such as telecommunications services, quality of port infrastructure, time delays in trade, and depth of credit information. They noted that their impacts varied across sectors or product groups.

Other studies that have applied the gravity model also emphasized the crucial role of infrastructure on trade. Shepherd and Wilson (2009) discovered that bilateral trade flows in Southeast Asia were affected by transport infrastructure, mainly ports and ICT. Hoekman and Nicita (2008) found that poor roads and ports, poorly performing customs agencies and procedures, weakness in regulatory capacity, and limited access to finance and business services affected trade. Wilson, Mann, and Otsuki (2005), when extending the gravity model to trade facilitation measures and to a larger sample of 75 economies, posited that port efficiency and the proxies for infrastructure quality for the services sector, such as the use, speed, and cost of the internet, significantly affected trade flows. Wilson, Mann, and Otsuki (2003) also found that that improving port and airport efficiency could positively impact intra-APEC trade.

Bougheas, Demetriades, and Morgenroth (1999), in developing a gravity model to analyze the effect of infrastructure on the volume of trade via its influence on transport costs, found that infrastructure had a significant and positive relationship to the level of infrastructure and the volume of trade. As a result, differences in transport costs among economies may highlight differences in their ability to compete in international markets. Furthermore, differences in the volume and quality of infrastructure may account for differences in transport costs and, hence, variations in competitiveness. Better transport services and infrastructure improve international market access and increase trade.

Limao and Venables (2001) employed a gravity model similar to that developed by Bougheas, Demetriades, and Morgenroth (1999), which included dummy variables representing possibilities of transit. Infrastructure was measured by variables including paved and unpaved roads, railways, and telephone lines. Infrastructure was found to be an important factor in determining transport costs, especially for landlocked countries. They estimated that differences in infrastructure accounted for 40% of transport costs for coastal countries and 60% for landlocked countries.

Adopting the study by Limao and Venables (2001), Nordas and Piermartini (2004) investigated the role of infrastructure on trade in the clothing, automotive, and textile sectors. Indicators included the quality of airports, roads, ports, and telecommunications, and the time required for customs clearance. In addition, it incorporated bilateral tariffs. Their study proved that trade performance was significantly affected by infrastructure quality, especially port efficiency. Timeliness was more significant for export competitiveness in the clothing sector, while access to telecommunications in the automotive sector was more significant. It also concluded that, even after the quality of infrastructure was included, distance remained a significant factor.

Djankov, Freund, and Pham (2010) claimed that infrastructure directly affected transport costs by influencing the type of transport used and delivery time of the goods. By using data on time to export and import, they estimated the impact of delays on trade, showing that trade decreased by at least 1% for every extra day taken to move goods from the warehouse to the ship, comparable to an increase in the distance of an economy from its trading partner by 70 kilometers.

Anderson and Van Wincoop (2004) demonstrated that trade costs were equivalent to a 170% ad-valorem tax for industrial economies. They estimated that transport costs were equivalent to 21% of 170% total trade in industrialized economies, while border-related barriers represented 44%, and distribution costs represented 55%. Time cost was particularly significant for perishable or other time-sensitive goods. Hummels (2001) discovered that the time cost of 1 day in transit for United States imports was equivalent to an ad-valorem tariff rate of 0.8%, suggesting a corresponding 16.0% tariff rate on an average trans-Pacific shipment of 20 days. Thus, improvements in infrastructure services that reduce delays in transit times, border-crossing procedures, or ports affect an economy's propensity to trade.

Only a few studies have investigated ICT's effect on trade flows, such as Fink et al. (2005), which revealed that that the high cost of making a telephone call had a significant negative effect on bilateral trade flows. Further, the impact of ICT was greater for trade of differentiated products than on trade of homogenous products. Nicoletti et al. (2003) found that ICT was particularly important for trade-in services due to its high dependence on well-developed infrastructure in both exporting and importing economies.

Francois and Manchin (2007), by using principal components to construct two indicators on infrastructure and institutional quality, found that institutional quality, along with transport and communications infrastructure, was a significant determinant for an economy's export levels as well as for prospective exports. The results support the belief that export performance depends on institutional quality and access to communications and transport infrastructure. In addition, Méon and Sekkat (2006) observed a positive relationship between poor institutional quality and low-quality manufacturing exports. Compared to government effectiveness or the rule of law, control of corruption was the most significant factor related to manufacturing exports. Another study by Anderson and Marcoullier (2002), who used data on contractual enforcement and corruption, discovered that lower institutional quality was associated with a negative effect on trade. Other similar empirical evidence is found in Depken and Sonora (2005) and Levchenko (2007).

Several studies have highlighted the significance of other forms of institutional quality, such as contract enforcement procedures, investor protection, and the rule of law on international trade. Ranjan and Lee (2007) employed a gravity model to examine the link between trade volumes and contract enforcement, suggesting that trade volumes were affected by the efficiency of contract enforcement. This finding was consistent with that of Duval and Utoktham (2009), who pointed out that if domestic contract enforcement procedures were shortened and simplified to that of the average of Organisation for Economic Co-operation and Development (OECD) member countries, it could raise merchandise exports by up to 27%. The impact of investor protection on trade was also studied by Hur, Raj, and Riyanto (2006), who noted that improved investor protection could stimulate economies' export and trade balances with relatively more intangible assets.

Several studies have tested the effect of transparency in customs administration and trade policy. Helble, Shepherd, and Wilson (2009), with their study on transparency in the trading environment for APEC members, used predictability and simplification measures to develop a new measurement of transparency, concluding that improving transparency in trade policy could reduce trade costs and subsequently boost intraregional trade. Sadikov (2007), in a sample of 126 economies, showed that troublesome business registration procedures and export signature requirements could have a negative effect on exports, and the impact was worse for differentiated products than homogeneous goods.

Some studies have also examined the link between trading time and trade flows. Djankov, Freund, and Pham (2010), in a sample of 126 economies on the length of time needed for transferring products from the factory to the ship, found that a delay of 1 day reduced trade by 1%, and the impact was larger for time-sensitive products such as agricultural goods. Duval and Utoktham (2009) showed a negative relationship between delivery cost and exports, in which a decrease in 5% of a delivery cost for a good to the closest port could increase exports at least by 4%.

3.2 Infrastructure and Growth

The theoretical analysis of the effect of infrastructure on growth lies at the root of growth theory. Arrow and Kurz (1970) incorporated infrastructure into the theory of growth literature. Infrastructure, as measured by public capital, was treated as an additional input in the aggregate production function in the framework of Ramsey-type exogenous growth models. Barro (1990) analyzed the impact of public capital in the framework of the endogenous growth model, and Futagami, Morita, and Shibata (1993) extended the study by adding private capital stock .

Empirical literature supports the role of infrastructure in promoting growth, such as in Aschauer (1989), Easterly and Rebelo (1993), and World Bank (1994). World Bank (1994) reviewed the importance of infrastructure on productivity growth and pointed out that infrastructure might influence economic development through its impacts on economic growth, poverty alleviation, and the environment. Economies with adequate and efficient infrastructure services had higher productivity growth than those with lower and inefficient infrastructure services. In addition, Canning (1998) provided a dataset on physical infrastructure stocks such as roads, paved roads, rail lines, electricity-generating capacity, telephones, and telephone lines for 152 economies for 1950–1995, which contained descriptions from the annual database of physical infrastructure constructed. Telephones and paved roads had significant impact on growth, while the others did not.

A few studies have specifically focused on the relevance of infrastructure to growth in East Asia. Seethepalli, Bramati, and Veredas (2008) looked at infrastructure subsectors, such as energy, sanitation, water supply, transport, and telecommunications, by applying standard growth regressions on 16 economies in East Asia. By controlling for the level of investment and human capital, the study showed a significant positive relationship between infrastructure and economic growth in all infrastructure indicators. In addition, it examined whether the relationship between infrastructure and growth was influenced by five variables: the degree of private participation in infrastructure, quality of governance, extent of rural–urban inequality in access to infrastructure, income levels, and geography. Only telecommunications and sanitation supported a priori hypothesis, while a contradictory result was found for roads.

In a similar study, Straub (2008) examined the impact of infrastructure investment on East Asia's economic growth using a growth-accounting framework and cross-country regression. Although the study used a similar set of economies as Seethepalli, Bramati, and Veredas (2008), the findings showed no significant impact of infrastructure on growth, contradicting the results of Seethepalli, Bramati, and Veredas (2008) when using a production function. When using cross-country growth regressions, the results were much weaker than those of Seethepalli, Bramati, and Veredas (2008), despite the use of infrastructure stocks rather than flows to lessen the problem of reverse causation.

Straub and Terada-Hagiwara (2011) extended this study using physical infrastructure indicators across four sectors: telecommunications, energy, transport, and water. Growth regressions and growth accounting were used, showing that the growth rate of stocks had a positive and significant impact on the growth rate of East Asia-Pacific and South Asia economies for most infrastructure indicators. However, the results from the growth-accounting exercise revealed that positive and significant effects of infrastructure on total factor productivity growth were only observed in the PRC, Republic of Korea, and Thailand for the telecommunications and energy indicators.

Calderón and Chong (2009) provided a comprehensive assessment of the impact of infrastructure development on economic growth in Africa by using physical indicators in the telecommunications, power, and transport sectors. Data for 136 countries for 1960–2005 were regressed by using nonoverlapping 5-year period observations. To address econometric issues such as unobserved country- and time-specific effects as well as potential reverse causality, an instrumental variable technique was employed. The study evaluated the impact on per capita growth of faster accumulation of infrastructure stocks and of enhancement in the quality of infrastructure services. The findings showed that growth was positively affected by infrastructure stocks and the quality of infrastructure services. The study also found that Africa is likely to gain greater benefits from larger stocks of infrastructure than from improving the quality of the existing infrastructure.

Calderón and Servén (2008) assessed the effects of infrastructure on economic growth and inequality, also with a specific focus on Sub-Saharan Africa. Their empirical results were based on a dataset of infrastructure quantity and quality indicators involving more than 100 economies covering 1960–2005. They demonstrated that an increase in the volume of infrastructure stocks and improved infrastructure quality had a positive impact on long-run growth and a negative impact on income inequality.

4. EMPIRICAL STRATEGY

4.1 Impact of Infrastructure on Trade

The first objective of this study is to examine the effects of infrastructure on trade flows in selected economies in Asia. Following the literature, an augmented gravity model was used to analyze the different types of infrastructure on bilateral trade flows in Asia. The estimation was carried out using the random effects model:

$$\begin{aligned} lnX_{ijt} = \beta_0 + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{jt} + \beta_3 lnEndow_{tijt} + \beta_4 lnDist_{ij} + \beta_5 lang_{ij} \\ + \beta_6 INFRA_{it} + INFRA_{jt} + HI_i + HI_j + \varepsilon_{ijt} \end{aligned} \quad (1)$$

where

i	=	economies in Asia
j	=	Asian trading partner (economy's top 20 export destinations)
X_{ijt}	=	economy *i* exports to economy *j* in year *t*
GDP_{it}	=	exporters' real GDP in year *t*
GDP_{jt}	=	importers' real GDP in year *t*
$Dist_{ij}$	=	distance in kilometers between capitals of economies *i* and *j*
Endowijt	=	relative endowment in absolute difference of GDP per capita between economies *i* and *j* in year *t*
$Lang_{ij}$	=	dummy for common language is 1 when economies *i* and *j* have the same language, or generally share the same linguistic heritage
$INFRA_{it}$	=	exporters' infrastructure in year *t*
$INFRA_{jt}$	=	importers' infrastructure in year *t*
HI_i	=	dummy for high-income exporters is 1 when economy *i* is high income
HI_j	=	dummy for high-income importers is 1 when economy *j* is high income

The GDP for both exporters and importers was a proxy for the market size, expected to have a positive relationship with exports, as the bigger the market size, the greater the likelihood of having more trade links. The relative endowment referred to the absolute difference of GDP per capita between exporters and importers to capture the level of development. The expected result was ambiguous, because the sample economies were mixed. The closer the income gap, the more likely the economy was to trade with income-similar economies and was expected to have a negative result. Transport costs were captured by a measure of distance between the two economies. The distance was negatively related to the trade volume between them; more trade occurs between economies within a short distance. A common language to capture the information cost was a dummy variable that took the value of 1 if the two economies shared a common language, and zero otherwise.

Infrastructure (INFRA) was divided into two categories, hard and soft. To provide a better understanding of impact, the estimation was carried out by testing the type of infrastructure for both exporters and importers.

The model also included a dummy variable equal to 1 if exporters and importers were high-income economies, and zero otherwise. The variables were used to control in the case of bias estimation with mixed sample economies. The dummy variables should have had more potential to trade with economies in Asia and thus had positive and significant results.

This study also estimated the impact of both hard and soft infrastructure on exports in the agriculture and manufacturing sectors. The following models were applied:

$$\boldsymbol{lnAX_{ijt} = \beta_0 + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{jt} + \beta_3 lnEndow_{tijt} + \beta_4 lnDist_{ij} + \beta_5 lang_{ij} + \beta_6 INFRA_{it} + INFRA_{jt} + HI_i + HI_j + \varepsilon_{ijt}} \tag{2}$$

$$\boldsymbol{lnMX_{ijt} = \beta_0 + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{jt} + \beta_3 lnEndow_{tijt} + \beta_4 lnDist_{ij} + \beta_5 lang_{ij} + \beta_6 INFRA_{it} + INFRA_{jt} + HI_i + HI_j + \varepsilon_{ijt}} \tag{3}$$

Where *AX* was exports in agriculture, and *MX* was exports in the manufacturing sector. The independent variables were the same as in (1). The impact of agriculture should have been on transport infrastructure rather than ICT infrastructure, but both sectors should have had the same impact on soft infrastructure.

The econometric issues of using a random-effect or fixed-effect model were considered. A random-effect model is a more appropriate approach in estimating typical trade flows through a randomly drawn sample of trading partners, particularly from a larger population. However, the fixed-effect model is a better choice for estimating trade between an ex-ante predetermined selection of economies (Egger 2000). In the case of the absence of any correlation between observable and panel-specific error terms, the random-effect approach is preferred. Implicitly, the fixed-effect model assumes that all explanatory variables are correlated with the unobserved effects or the specific error term that eliminates this correlation within the transformation. Yet the fixed-effect model wipes off all time-invariant variables, such as distance and language. Therefore, to allow distance and language as proxies for transactions and information cost, respectively, the random effects model was used.

4.1.1 Data Source

Export data for aggregate, agriculture, and manufacturing were assessed from the United Nations Commodity Trade Statistics Database, SITC 3 at 1-digit for 2003 to 2013.[2] Distance and language were taken from the CEPII database.[3] Other indicators such as GDP and GDP per capita are from World Development Indicators, World Bank.[4]

[2] http://comtrade.un.org/db/
[3] http://www.cepii.fr/CEPII/en/welcome.asp
[4] http://data.worldbank.org/data-catalog/world-development-indicators

4.2 Impact of Infrastructure on Economic Growth

The second objective of this study is to investigate the effects of the quality and quantity of infrastructure on economic growth. For the growth model, a pooled mean group estimation (PMGE) was carried out:

$$lnY_{it} = \alpha_0 + \alpha_1 lnPOP_{it} + \alpha_2 lnk_{it} + \alpha_3 lnOpen_{it} + \alpha_4 lnHC_{it} + \alpha_5 lnINFRA_{it} + \varepsilon_{it} \quad (4)$$

where

Y	=	real GDP per capita (in 2000 purchasing power parity [PPP] terms)
POP	=	population growth
k	=	physical capital as measured by gross fixed capital formation relative to GDP
OPEN	=	trade openness (i.e., real value of exports and imports as percentage of GDP)
HC	=	human capital (i.e., school enrollment at the secondary level)
INFRA	=	infrastructure
Ln	=	logarithm

The dependent variable used was the economic growth proxy by real GDP per capita *Y* at constant terms. A standard set of control variables, including population growth, was expected to have a negative relationship with economic growth. Investment *k* was measured by gross fixed capital formation relative to GDP, and was expected to have a positive effect on growth. Additional variables were also included such as trade openness and human capital proxy, which were interpolated from Barro and Lee (2010) as control variables and expected to have positive effects on economic growth.

Following Calderón and Chong (2009) and Sahoo et al. (2010), the indicators used to represent infrastructure quantity-related measures for the transport sector were freight air transport, air transport passengers carried, and the length of the total roads network. For quality measures of infrastructure, paved roads were used as a proxy. Two ICT indicators were used to measure the quantity of infrastructure, the number of telephone lines and mobile phone subscribers, and were expected to have positive effects on economic growth. For the quality of infrastructure, the number of internet users was identified as a proxy, as the more people who use the internet, the more that they are connected and benefit through the transfer of communication and knowledge, leading to higher productivity and economic growth.

Finally, the energy sector was represented by power consumption per capita. The use of energy consumption could be value added to output, as energy was one of the input sources in the production function. This benefit could be seen if the use was shifted from less-efficient energy consumption to more efficient to stimulate economic growth. Thus, the quality of energy infrastructure, such as alternative and nuclear energy (percentage of total energy) and electric power transmission and distribution losses (percentage of total output) were used to capture the effects on economic growth. Electric power transmission and distribution losses should have had negative effects on economic growth, while alternative and nuclear energy should have contributed positively to growth.

Given the long-run growth of Asia, the PMGE developed by Pesaran, Shin, and Smith (1999) was deemed to be an appropriate approach, as it allowed for heterogeneity in the short-run coefficients but restricted the long-run coefficients as the same for all economies. The Hausman test (Hausman 1978) was used to test the null hypothesis of homogeneity in the long-run parameters.

Panel analysis on the unrestricted specification for the autoregressive distributed lag (ARDL) model for time periods *t* = 1,2,…..,*T*; groups *i* = 1,2,…,*N;* and the dependent variable y was:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij}\, y_{i,t-j} + \sum_{j=0}^{q} \gamma_{ij}^{\prime}\, x_{i,t-j} + \mu_i + \varepsilon_{it} \qquad (5a)$$

where y_{it} was a scalar dependent variable, x_{it} was the *k* x 1 vector of explanatory variables for group *i*, μ_i denoted the fixed effects, λ_{ij}s were scalar coefficients of the lagged dependent variables, and $\gamma_{ij}^{\prime}$ s were *k* x 1 coefficient vectors.

The re-parameterized form was formulated as

$$\Delta y_{it} = \phi_i y_{i,t-1} + \beta_i^{\prime}\ x_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij}\, \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \gamma_{ij}^{\prime}\, \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \qquad (5b)$$

It was assumed that the disturbances ε_{it}s were independently distributed across *i* and *t,* with zero means and variances $\sigma_i^2 > 0$. It was assumed further that $\phi_i < 0$ for all *i*. Thus, there existed a long-run relationship between y_{it} and x_{it} defined by

$$y_{it} = \theta^{\prime}\ x_{it} + \eta_{it}\ i\ =\ 1,2, \ldots \ldots . N;\ \ t\ =\ 1,2, \ldots \ldots \ldots T$$

where $\theta_i = -\beta^{\prime}{}_i / \theta_i$, was the *k* x 1 vector of the long-run coefficients, and $\eta_{it}s$ were stationary with possibly nonzero means (including fixed effects). Hence, (5b) could be written as

$$\Delta y_{it} = \phi_i \eta_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij}\, \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \gamma_{ij}^{\prime}\, \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \qquad (5c)$$

where $\eta_{i,t-1}$ was the error correction term given by (5c), and thus ϕ_i was the error-correction term coefficient measuring the speed of adjustment toward the long-run equilibrium.

The PMG method of estimation allowed short-run coefficients, intercepts, and error variances to vary across economies but constrained the long-run coefficients to be equal. This implied that $\theta_i = \theta$ for all *i*. To estimate short-run coefficients and the common long-run coefficients, Pesaran, Shin, and Smith (1999) adopted the pooled maximum likelihood estimation approach by assuming that the disturbances ε_{it} were normally distributed. These PMG estimators were denoted by:

$$\widehat{\emptyset}_{PMG} = \frac{\sum_{i=1}^{N} \widetilde{\emptyset}_i}{N}\ ,\qquad \hat{\beta}_{PMG} = \frac{\sum_{i=1}^{N} \widetilde{\beta}_i}{N} \qquad \hat{\lambda}_{jPMG} = \frac{\sum_{i=1}^{N} \widetilde{\lambda}_{ij}}{N}\ ,\quad j = 1,\ldots, p\text{-}1 \ \text{ and}$$

$$\hat{\gamma}_{jPMG} = \frac{\sum_{i=1}^{N} \widetilde{\gamma}_{ij}}{N}\ , j = 0,\ldots, q\text{-}1,\ \ \hat{\theta}_{PMG} = \tilde{\theta}$$

The final PMG procedure was:

$$\Delta lny_{it} = -\phi_i\left(lny_{i,t-1} - \theta_1 lnk_{i,t} - \theta_2 lHC_{i,t} + \theta_3 nPOP_{i,t} - \sum_j^m \theta_j lnINFRA_{i,t}^j - a_{m+1}t_i - \theta_{0,i}\right) + b_{1,i}\Delta lnk_{it} + b_{2,i}\Delta lnHC_{i,t} + b_{3,i}\Delta POP_{i,t} + \sum_j^m b_{j,i}\Delta lnINFRA_{i,t}^j + \varepsilon_{i,t} \quad (6)$$

4.2.1 Data Sources

The data for physical infrastructure indicators were taken from Canning (1998), and extended through World Bank (2014). ICT data were from International Telecommunication Union World Telecommunication/ICT Indicators database.[5] Other variables, such as GDP per capita, openness, population growth, and gross capital formation, were taken from World Bank (2014). The dataset was for the PRC; Hong Kong, China; India; Indonesia; Republic of Korea; Malaysia; Philippines; Singapore; Thailand; and Viet Nam from 1971 to 2013.

5. RESULTS AND DISCUSSION

5.1 Transport Infrastructure and Trade Flows

Table 5 shows the effects of transport infrastructure on trade flows. The study used various indicators to represent airports, ports, rail, and roads. The four selected indicators were air traffic freight, container port traffic, rail networks, and paved roads.

The basic line of the gravity model shows that the coefficients for the market size for both exporters and importers are positive and statistically significant. This suggests that bigger market size implies higher trade flows of economies. The coefficient for relative endowment is positive but insignificant. As expected, distance exerts a strong negative impact on trade flows, consistent with the theory that the shorter the distance, the lower the transaction costs and the more trade. The coefficient of common language is also as expected, positive and statistically significant. The coefficient of high-income dummies for exporters and importers is also positive and significant, as trade increases by 1.5 times and 1.3 times[6] if the economies are high income.

Air traffic freight was used as a proxy for airport infrastructure for exporters; the result is positive but insignificant. However, the airport infrastructure for importers is positive and significant. For other types of infrastructure, the results reveal that both road and port infrastructures play significant roles in trade in both exporting and importing economies. For instance, a 10% increase in road density has the effect of a 1% increase in trade. As revealed in much of the literature, port infrastructure is equally important in determining trade in economies in Asia.

[5] http://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx
[6] The exponential (0.425) = 1.5, and the exponential (0.267) = 1.3.

Table 5: Transport Infrastructure Effects on Exports in Asia

	Basic Model	Airport Infrastructure		Roads Infrastructure		Railway Infrastructure		Port Infrastructure		Full Model	
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GDP, exports	0.8690^{c}	0.6400^{c}	0.6040^{c}	0.5630^{c}	0.5470^{c}	0.8360^{c}	0.7760^{c}	0.5620^{c}	0.5450^{c}	0.7150^{c}	0.6260^{c}
	(14.65)	(23.03)	(31.28)	(24.21)	(21.00)	(24.67)	(19.70)	(28.37)	(27.46)	(24.25)	(15.75)
GDP, imports	0.4510^{c}	0.4620^{c}	0.4620^{c}	0.4550^{c}	0.4420^{c}	0.4900^{c}	0.6490^{c}	0.4750^{c}	0.4320^{c}	0.4470^{c}	0.5070^{c}
	(27.94)	(26.98)	(23.52)	(20.96)	(17.47)	(23.13)	(17.14)	(24.92)	(21.90)	(21.82)	(10.78)
Endowment	0.0006	–0.0020	–0.0040	–0.0050	–0.0070	0.1570^{c}	0.1360^{c}	0.0020	0.0008	–0.0097	–0.0080
	(0.09)	(–0.38)	(–0.63)	(–0.58)	(–0.81)	(7.03)	(5.33)	(0.25)	(0.11)	(-1.09)	(-.80)
Distance	–0.7980^{c}	–0.8120^{c}	–0.8230^{c}	–0.8240^{c}	–0.7540^{c}	–0.8980^{c}	–0.7380^{c}	–0.840^{c}	–0.7630^{c}	–0.8170^{c}	–0.6510^{c}
	(–24.90)	(–23.98)	(–22.03)	(–19.30)	(–15.81)	(–21.41)	(–11.30)	(–22.46)	(–19.48)	(–20.27)	(–9.69)
Language	0.2140^{c}	0.2620^{c}	0.3430^{c}	0.3980^{c}	0.4550^{c}	0.0350	–0.3710^{c}	0.2880^{c}	0.2230^{c}	0.3330^{c}	0.1960^{a}
	(3.40)	(4.07)	(5.14)	(5.29)	(5.41)	(0.38)	(–2.91)	(4.34)	(3.31)	(4.67)	(1.99)
Exporters, high-income	0.4250^{a}	0.4310^{c}	0.4220^{c}	0.2710^{c}	0.2250^{c}	–0.2820^{c}	–0.2900^{c}	0.4090^{c}	0.4040^{c}	–0.0599	–0.0910
	(1.85)	(5.79)	(8.48)	(4.53)	(3.28)	(–3.29)	(–2.87)	(7.91)	(7.79)	(–0.86)	(-0.99)
Importers, high-income	0.2670^{c}	0.2730^{c}	0.2930^{c}	0.3100^{c}	0.2480^{c}	–0.0160	–0.5540^{c}	0.2900^{c}	0.2660^{c}	0.3190^{c}	–0.4900
	(5.46)	(5.27)	(5.04)	(4.72)	(3.33)	(–0.21)	(–4.71)	(5.01)	(4.49)	(5.14)	(–0.41)
Air transport, exports		0.0050	0.0020							0.0330^{c}	0.3770^{c}
		(0.65)	(0.28)							(3.22)	(2.90)
Air transport, imports			0.0230^{b}								0.0590^{c}
			(2.16)								(3.04)
Road density, exports				0.1090^{c}	0.0970^{c}					0.1420^{c}	–0.1260^{c}
				(5.04)	(3.76)					(–9.77)	(–6.32)
Road density, imports					0.0700^{c}						–0.0090
					(3.02)						(–0.63)
Railway, exports						–0.0820^{c}	–0.0890^{c}				Drop
						(–5.33)	(–4.91)				
Railway, imports							–0.0070				0.0007
							(–0.38)				(0.03)
Container port traffic, exports								0.1450^{c}	0.1540^{c}	0.1580^{c}	0.1730^{c}
								(8.64)	(8.98)	(9.01)	(7.01)
Container port traffic, imports									0.1650^{c}		0.1170^{c}
									(7.80)		(4.06)
Constant	–6.5500^{c}	–0.7290	0.1330	1.1680	1.2000	–6.4500^{c}	–9.9700^{c}	–1.1700^{a}	–3.0300^{c}	–3.3200^{c}	–6.6300^{c}
	(–4.13)	(–0.87)	(0.19)	(1.41)		(–7.06)	(–7.06)	(–1.68)	(–4.07)	(–3.78)	(3.99)
Wald Chi2	1,342.66	1,539.27	1,539.27	1,227.93	908.60	2,065.12	1,555.94	1,956.41	2,031.94	1,569.85	1,007.20
No obs	1,972	1,972	1,932	1,472	1,157	1,112	726	1,774	1,670	1,436	826

GDP = gross domestic product.
[a] = significance at the 1% level
[b] = significance at the 5% level
[c] = significance at the 10% level
Number in parentheses are *t*-statistics.

Columns 9 and 10 provide a full model in which all infrastructure is included in the equations. The results confirm that air transport and port facilities, such as the availability of containers, are significantly important to both exporters and importers.

5.2 Information and Communication Technology Infrastructure and Trade Flows

Table 6 demonstrates the results of the estimation of ICT infrastructure variables on trade flows. Five indicators were chosen as proxies for ICT infrastructure: number of telephone lines, fixed mobile phones, mobile phone subscriptions, broadband, and internet users and secure internet servers.

The GDPs for exporters and importers are positive and significant, with the estimated coefficient ranging from 0.5 to 0.9 for exporters, and from 0.4 to 0.6 for importers. All ICT infrastructure variables are statistically significant and positively related to trade, except for the number of internet users for exporters in column 7; however, when the number of internet users for importer economies is included, the result is positive and significant.

These results are in line with the findings of Nicoletti et al. (2003); Fink, Mattoo, and Neagu (2005); Shepherd and Wilson (2009); and Li and Wilson (2009), all of whom also revealed that the role of ICT is important in international trade. These results also confirmed that two-way communications between exporters and importers with good ICT facilities benefit both trading partners. For instance, a 10% increase in the number of fixed and mobile phone subscribers for both exporters and importers boost trade by 2.6% and 2.2%, respectively. Although some countries such as India, Indonesia, and Viet Nam are still underdeveloped in terms of internet security, the results exert a positive significance for both exporters and importers. As such, a 10% increase in internet security in exporters and importers will raise trade by 0.65% and 0.67%, respectively.

Table 6: Effects of Information and Communications Technology Infrastructure on Exports in Asia

	Telephone Lines		Mobile Phones		Fixed Broadband		Internet Users		Security Internet		Full Model	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GDP, exports	0.6510[c]	0.6080[c]	0.5930[c]	0.6200[c]	0.5700[c]	0.5620[c]	0.9300[c]	0.5990[c]	0.6270[c]	0.6050[c]	0.5660[c]	0.5890[c]
	(20.30)	(33.00)	(10.50)	(33.34)	(19.35)	(30.96)	(14.12)	(31.76)	(25.10)	(32.59)	(13.11)	(13.62)
GDP, imports	0.4540[c]	0.4390[c]	0.4440[c]	0.4580[c]	0.4430[c]	0.4190[c]	0.4490[c]	0.4550[c]	0.4560[c]	0.4490[c]	0.4380[c]	0.3740[c]
	(27.14)	(24.05)	(27.60)	(24.97)	(26.53)	(23.19)	(27.88)	(24.40)	(26.42)	(24.48)	(24.15)	(10.26)
Endowment	0.0050	0.0040	0.0080	0.0050	0.0100	0.0160[c]	0.0010	0.0009	0.0000	–0.0000	0.0150[c]	0.0100
	(0.76)	(0.70)	(1.18)	(0.74)	(1.52)	(2.34)	(0.16)	(0.13)	(0.05)	(–0.07)	(2.15)	(1.40)
Distance	–0.8030[c]	–0.7920[c]	–0.7880[c]	–0.7680[c]	–0.7840[c]	–0.7580[c]	–0.7960[c]	–0.8050[c]	–0.8060[c]	–0.8210[c]	–0.7760[c]	–0.7790[c]
	(–24.23)	(–22.18)	(–24.76)	(–21.37)	(–23.77)	(–21.60)	(–24.92)	(–22.00)	(–23.60)	(–22.75)	(–21.15)	(–20.70)
Language	0.2510[c]	0.3610[c]	0.2130[c]	0.3280[c]	0.2650[c]	0.3550[c]	0.2110[c]	0.3350[c]	0.2780[c]	0.3160[c]	0.3570[c]	0.3420[c]
	(3.96)	(5.69)	(3.42)	(5.20)	(4.23)	(5.70)	(3.36)	(5.13)	(4.34)	(4.89)	(5.91)	(5.33)
Exporters, high-income	0.0910	–0.1180[c]	0.2580	0.2140[c]	0.0220	–0.0460	0.4200	0.3340[c]	0.2450[c]	0.1720[c]	–0.0620	–0.0320
	(0.84)	(–1.86)	(1.55)	(4.09)	(0.26)	(–0.79)	(1.39)	(6.67)	(3.33)	(3.03)	(–0.88)	(–0.46)
Importers, high-income	0.2600[c]	0.0392	0.2550[c]	0.0960	0.2510[c]	0.0020	0.2670[c]	0.2050[c]	0.2690[c]	0.0360	0.2450[c]	–0.0120
	(5.14)	(0.57)	(5.25)	(1.56)	(4.98)	(0.04)	(5.48)	(3.49)	(5.15)	(0.56)	(4.49)	(–0.16)
Telephone lines, exports	0.2490[c]	0.3960[c]									0.2150[c]	0.2630[c]
	(5.28)	(12.52)									(5.16)	(6.52)
Telephone lines, imports		0.1890[c]										0.0170
		(5.07)										(0.34)
Mobile, exports			0.2310[c]	0.2660[c]							0.1320[c]	0.1110[a]
			(7.44)	(9.66)							(2.27)	(1.90)
Mobile, imports				0.2170[c]								0.1210[c]
				(5.84)								(2.18)
Broadband, exports					0.1530[c]	0.1760[c]					0.0520[b]	0.0320
					(9.71)	(13.14)					(2.01)	(1.22)
Broadband, imports						0.1070[c]						0.0220
						(6.68)						(0.81)
Internet users, exports							0.0010	0.0870[c]			0.0660[c]	0.0420[a]
							(0.16)	(7.27)			(2.74)	(1.66)
Internet users, imports								0.0660[c]				0.0640[c]
								(3.99)				(2.40)
Secure internet server, exports									0.0480[c]	0.0650[c]	–0.0100	–0.0280
									(5.70)	(8.20)	(–0.46)	(–1.26)
Secure internet server, imports										**0.0670[c]**		**0.0520[c]**
										(6.57)		**(2.38)**
Constant	–1.5160	–0.9720	–0.1640	–2.4100[c]	1.2750	1.765[c]	–8.1300[c]	0.0190	0.3510	0.3520	–0.4880	–0.2680
	(–1.63)	(–1.47)	(–0.11)	(–3.55)	(1.47)	(2.73)	(–4.65)	(0.03)	(–0.45)	(0.53)	(–0.48)	(–0.21)
Wald Chi2	1,501.07	2,159.36	1,447.90	2,208.24	1,681.45	2,378.20	1,339.69	1,992.92	1,661.12	2,094.86	2,218.46	2,289.17
No obs	1,954	1,945	1,972	1,972	1,972	1,962	1,972	1,952	1,972	1,962	1,954	1,905

GDP = gross domestic product.
[a] = significance at the 1% level
[b] = significance at the 5% level
[c] = significance at the 10% level
Numbers in parentheses are *t*-statistics.

Table 7: Effects of Soft Infrastructure on Exports in Asia

	Cost to Export or Import		Documents Needed to Export or Import		Time to Export or Import		Full Model for Export	Full Model for Import
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP, exports	0.6580[c]	0.7220[c]	0.7040[c]	0.6910[c]	0.6740[c]	0.7090[c]	0.7190[c]	0.7220[c]
	(7.83)	(32.07)	(28.99)	(26.67)	(30.38)	(31.12)	(27.55)	(29.68)
GDP, imports	0.4400[c]	0.4660[c]	0.4540[c]	0.4490[c]	0.4520[c]	0.4980[c]	0.4420[c]	0.4380[c]
	(25.01)	(22.62)	(22.52)	(21.31)	(22.85)	(22.79)	(22.55)	(22.09)
Endowment	0.0070	0.0040	–0.0010	–0.0040	0.0060	–0.0130	0.0090	0.0060
	(0.77)	(0.43)	(–0.18)	(–0.42)	(0.66)	(–1.24)	(0.39)	(0.60)
Distance	–0.7910[c]	–0.7970[c]	–0.8260[c]	–0.8450[c]	–0.8230[c]	–0.7780[c]	–0.8080[c]	–0.8090[c]
	(–22.71)	(–18.64)	(–20.89)	(–20.09)	(–21.15)	(–18.72)	(21.07)	(–20.84)
Language	0.1890[c]	0.0980	0.3210[c]	0.2810[c]	0.2580[c]	0.1190[a]	0.1560[c]	0.1620[c]
	(2.75)	(1.34)	(4.61)	(3.79)	(3.76)	(1.67)	(2.21)	(2.28)
Exporters, high-	0.4320	0.4790[c]	0.1790	0.1790[c]	0.0810	–0.0240	0.3140[c]	0.3100[c]
income	(1.37)	(9.11)	(2.67)	(2.54)	(1.13)	(–0.33)	(4.42)	(4.48)
Importers, high-	0.2390[c]	0.3010[c]	0.2700[c]	0.3320[c]	0.2550[c]	–0.1650[c]	0.2610[c]	0.2650[c]
income	(4.46)	(4.73)	(4.36)	(4.73)	(4.19)	(–2.05)	(4.36)	(4.39)
Cost, exports	0.4280[c]	–1.2900[c]					–1.2010[c]	
	(2.59)	(–12.83)					(–11.61)	
Cost, imports		–0.1590[c]						–0.8250[c]
		(–3.14)						(–8.83)
Documents, exports			–0.6170[c]	–0.5780[c]			0.3260[c]	
			(–6.55)	(–5.56)			(2.24)	
Documents, imports				0.1250[c]				–0.2060[a]
				(2.20)				(1.69)
Time, exports					–0.5150[c]	–0.5080[c]	–0.4130[c]	
					(–7.76)	(–7.38)	(–4.61)	
Time, imports						–0.4860[c]		0.0010
						(–8.60)		(0.02)
Constant	–3.4700	6.1300[c]	–1.0000	–0.6220	0.1330	–0.7270		
	(–1.67)	(7.36)	(–1.35)	(–0.79)	(0.18)	(–0.95)		
Wald Chi2	988.47	1,743.81	1,689.62	1,522.50	1,681.28	1,739.21	1,871.93	1,807.19
No obs	1,597	1,488	1,648	1,504	1,647	1,355	1,596	1,580

GDP = gross domestic product.
[a] = significance at the 1% level
[b] = significance at the 5% level
[c] = significance at the 10% level
Number in parentheses are *t*-statistics.

5.3 Soft Infrastructure and Trade Flows

Table 7 shows the results of soft infrastructure for both exporters and importers on trade. The three indicators of soft infrastructure were cost to export and import, documents needed to export and import, and time to export and import.

The GDP and other control variables (i.e., distance, common language, and dummy) for high-income economies have results similar to the model for hard infrastructure. The coefficients for the costs of imports and exports are negative with trade, which indicates that when the cost of doing business is lower for exporters or importers, the potential trade is higher. These results are similar to those of Sadikov (2007); Duval and Utoktham (2009); and Djankov, Freund, and Pham (2010), who also found a negative relationship between the cost of exports and international trade.

Another indicator of soft infrastructure—documents needed for export and import—has a negative impact on trade. A 10.0% increase in the numbers of documents for export and import reduces trade by at least 5.5%. According to Doing Business 2014 published by World Bank, among selected Asian economies, the number of documents to export has been reduced to three in Hong Kong, China; Republic of Korea; and Singapore; and eight for the PRC.

Time to export and import is based on the number of days from a procedure starts until it is completed. The fewer days to complete the export procedure, the more potential trade. Specifically, a 10% reduction in the time to export increases trade by 5%, while time to import increases trade by 4%. This result supports the study of Djankov, Freund, and Pham (2010), which also confirmed a negative relationship between time and trade.

5.4 Effects of Infrastructure on Agricultural and Manufacturing Exports

Table 8 reveals that air transport and container port traffic are among the indicators that positively and significantly affect export manufacturing. From aggregate export data, air transport and port traffic are equally important in Asian economies. Similar results are found in agricultural exports. In addition, road density still matters for agricultural exports, as heavy products need transport via roads.

Table 8: Transport Infrastructure Effects on Agricultural and Manufacturing Exports

	Manufacturing Exports		Agricultural Exports	
	(1)	(2)	(3)	(4)-FEM
GDP, exports	1.0290[c]	0.9920[c]	0.2662[c]	0.4540
	(35.62)	(31.84)	(2.64)	(1.41)
GDP, imports	0.4470[c]	0.4880[c]	0.5290[c]	0.4940[c]
	(22.25)	(19.40)	(14.01)	(8.24)
Endowment	0.0230[c]	0.0310[c]	–0.0640[a]	–0.3510[c]
	(2.69)	(3.47)	(–1.89)	(–8.40)
Distance	–1.0700[c]	–0.9650[c]	–1.1170[c]	
	(–27.15)	(–22.62)	(14.76)	
Language	–0.2220[c]	–0.1580[c]	0.3011[c]	
	(–3.18)	(–2.15)	(–1.91)	
Exporters, high-income	–0.2750[c]	–0.3400[c]		
	(–4.03)	(–6.45)		
Importers, high-income	–0.0340	–0.2430[c]		
	(–0.58)	(–3.48)		
Air transport, exports	0.0480[c]	0.0380[c]	0.0990[c]	–0.0137
	(4.90)	(3.69)	(4.47)	(–0.33)
Road density, exports	–0.1180[c]	–0.1210	0.3890[c]	–0.2300
	(–8.25)	(–7.65)	(3.78)	(–0.54)
Railways, exports	dropped	dropped	–0.0630	–0.889
			(–0.72)	(–1.61)
Container port traffic, exports	0.1020[c]	0.1090[c]	–0.1440[c]	0.9580
	(5.96)	(5.69)	(–4.47)	(1.87)
Air transport, imports		0.0550[c]		0.0980[c]
		(4.49)		(3.36)
Road density, imports		–0.0080		0.0440[b]
		(–0.86)		(1.85)
Railways, imports		dropped		–0.1040 [c]
				(–3.03)
Container port traffic, imports		0.1350[c]		0.3270[c]
		(6.01)		(7.06)
Constant		–14.7900[c]	5.1720[a]	–12.2300[a]
		(–14.82)	(1.72)	(–1.70)
Wald Chi2	2,770.25	2,603.37	500.56	27.83
No obs	1,439	1,105	899	508

GDP = gross domestic product.
[a] = significance at the 1% level
[b] = significance at the 5% level,
[c] = significance at the 10% level.
Numbers in parentheses are t-statistics.

Table 9: Information and Communications Technology Infrastructure Effects on Agricultural and Manufacturing Exports

	Manufacturing Exports			Agricultural Exports	
	(1)	**(2)-FEM**	**(3)**	**(4)**	**(5)**
GDP, exports	0.9560[c]	0.0367	0.9560[c]	0.3250[c]	0.3448[c]
	(22.88)	(.16)	(22.51)	(5.13)	(5.42)
GDP, imports	0.4640[c]	0.1350[c]	0.5031 [c]	0.5690[c]	0.3610[c]
	(26.72)	(8.13)	(14.79)	(21.33)	(6.74)
Endowment	0.0350[c]	–.0035	0.0355[c]	0.0450[c]	0.0450[c]
	(5.18)	(–0.40)	(5.04)	(4.33)	(4.27)
Distance	–1.0800[c]		–1.0420[c]	–1.0000[c]	–0.9880[c]
	(–34.02)		(–29.26)	(19.14)	(–17.81)
Language	–0.2010[c]		–0.1770[c]	–0.0730	–0.0610
	(3.31)		(–2.84)	(–0.78)	(–0.64)
Exporters, high-income	dropped			–1.6600[c]	–1.6200[c]
				(–6.53)	(–15.51)
Importers, high-income	dropped			–0.5210[c]	–0.3850[c]
				(–6.53)	(–3.35)
Telephone lines, exports	0.2080[c]	–0.2410[c]	0.2390[c]	0.2030[c]	0.2660[c]
	(6.19)	(–2.13)	(6.79)	(3.32)	(4.30)
Mobile phones, exports	0.1180[c]	–0.3210	0.0880	–0.0420	–0.1000
	(2.11)	(–0.23)	(1.53)	(–0.49)	(–1.16)
Broadband, exports	0.0070	0.1160	0.0030	0.0570	0.0460
	(0.28)	(1.61)	(0.14)	(1.49)	(1.20)
Internet users, exports	–0.0080	0.1660[c]	–0.0170	0.0490	0.0260
	(–0.34)	(2.67)	(–0.73)	(1.38)	(0.72)
Secure internet servers, exports	–0.0327	0.1550[c]	–0.0399[a]	0.0860[c]	0.0540
	(1.62)	(3.98)	(–1.94)	(2.60)	(1.62)
Telephone lines, imports			–0.1530[c]		–0.2710[c]
			(–3.63)		(–3.75)
Mobile phones, imports			0.2110		–0.0540
			(4.08)		(–0.67)
Broadband, imports			0.0060		0.2220[c]
			(0.24)		(5.41)
Internet users, imports			–0.0290		0.2310[c]
			(–0.98)		(6.08)
Secure internet servers, imports			–0.0210		–0.0230
			(–0.98)		(0.72)
Constant	–10.0520[c]	12.9300[c]	–11.7200[c]		4.7000[c]
	(–10.18)	(2.38)	(–9.78)		(2.56)
Wald Chi2	4,044.41	34.18	4,001.46	1,288.77	1,360.37
No obs	1,961	1,961	1,912	1,958	1,909

GDP = gross domestic product.
[a] = significance at the 1% level
[c] = significance at the 10% level
Numbers in parentheses are t-statistics.

Table 9 shows that telephone lines and internet security indicators are positive and statistically significant for both agricultural and manufacturing exports. Communication infrastructure is important to businesses because it not only communicates to finalize a contract but also ensures security, especially for internet banking that allows transactions to be wired throughout the world.

Table 10 reports the effects of soft infrastructure on agricultural and manufacturing exports. The negative relationship between cost to export and time to export for manufacturing exports implies that economies in Asia export more manufacturing products if the cost is reduced and the time is shorter. However, documents needed to export are negative but insignificant. On the other hand, in practice, agricultural products need more documents than manufacturing products because some products are sensitive and require chemical tests.

Table 10: Soft Infrastructure Effects on Agricultural and Manufacturing Exports

	Manufacturing Exports		Agricultural Exports	
	(1)	(2)	(3)	(4)
GDP, exports	1.0120[c]	0.9760[c]	0.6250[c]	0.5112[c]
	(39.03)	(39.99)	(16.49)	(14.19)
GDP, imports	0.4620[c]	0.4630	0.5630	0.5670[c]
	(23.58)	(23.26)	(19.71)	(19.33)
Endowment	0.0255[c]	0.0290[c]	0.0210	0.0390[c]
	(2.45)	(2.79)	(1.40)	(2.55)
Distance	–1.0450[c]	–1.0500[c]	–0.9850[c]	–0.9930[c]
	(–27.35)	(–27.06)	(–17.68)	(–17.32)
Language	–0.2510[c]	–0.2750[c]	–0.0730	–0.1680
	(–3.55)	(–3.86)	(–0.71)	(–1.60)
Exporters, high-income	–0.0430	0.0380	–1.6400[c]	–1.3700[c]
	(–0.61)	(0.56)	(–15.89)	(–13.42)
Importers, high-income	–0.1180[b]	–0.1220[c]	–0.5120[c]	–0.5430[c]
	(–1.99)	(–2.01)	(–5.91)	(–6.09)
Cost, exports	–0.5110[c]		–0.0510	
	(–4.95)		(–0.34)	
Documents, exports	–0.2490		–1.4800[c]	
	(–1.73)		(–7.05)	
Time, exports	–0.1618[a]		0.2160	
	(–1.81)		(1.66)	
Cost, imports		–0.3640[c]		–0.2640[b]
		(–3.89)		(–1.91)
Documents, imports		0.0020		0.4960[c]
		(0.02)		(2.74)
Time, imports		–0.1150		–0.4430[c]
		(–1.38)		(–3.62)
Constant	–6.5520[c]	–7.0180[c]	–1.4180	1.3170
	(–7.34)	(–8.65)	(1.09)	(1.10)
Wald Chi2	3,128.53	2,987.73	1,097.72	986.73
No obs	1,600	1,584	1,599	1,583

GDP = gross domestic product.
[a] = significance at the 1% level
[b] = significance at the 5% level,
[c] = significance at the 10% level.
Numbers in parentheses are t-statistics.

5.5 Impact of Infrastructure on Economic Growth

This section discusses results for growth quantity related-infrastructure and employs the PMGE developed by Pesaran, Shin, and Smith (1999). Prior to analysis, the PMGE and mean group were regressed, and the Hausman test was applied. In the case of *p* being greater than 0.05, the PMGE was preferred and appropriate. Table 11 reports transport infrastructure, and Table 12 reports ICT and energy infrastructure.

The numbers of estimation were regressed to apply to all types of transport infrastructure and both quantity and quality. However, only four types of infrastructure are positive and significant. The findings show that all indicators of quantity-related transport infrastructure—road total network, air transport for passengers and registered freight—have a positive and significant coefficient at least at the 5% significance level. The results are in line with many studies that emphasize the development of infrastructure such as roads and air transport. Having long total road networks leads to easier access to the work place, thus increasing productivity and encouraging economic growth.

Column 2 reports the result for the quality of transport infrastructure, that is, paved roads. A 10% increase in paved roads increases economic growth more than 5%. Quality, such as paved roads, reduces the cost of vehicle maintenance, thus increasing worker productivity. The results confirm that the quality of infrastructure matters, as economies perform better in economic growth. However, the quantity of infrastructure may not be sufficient for Asia, which mainly focuses on the manufacturing sectors.

Table 11: Transport Infrastructure Effects on Economic Growth

	Total Road	Paved Road (Quality)	Air Transport Passengers	Air Transport Registered Freight	Full Model
	(1)	(2)	(3)	(4)	(5)
Population growth	–0.1668	–0.0050	–0.1002[c]	–0.1214	–0.7040[c]
	(–1.25)	(–0.17)	(–2.31)	(–1.59)	(4.29)
Investment	1.7680[c]	–0.2750[c]	–0.0147	–0.1497	0.3750[c]
	(6.31)	(–3.96)	(–0.31)	(–1.59)	(–5.09)
Trade openness	0.5257[c]	1.0390[c]	0.5300[c]	0.7582[c]	0.1290[c]
	(6.27)	(11.27)	(7.55)	(6.20)	(2.49)
Road total network	0.4222[c]				0.2450[c]
	(5.50)				(3.47)
Paved road		0.5480[a]			0.2420[c]
		(1.79)			(2.74)
Air transport,			0.3748[c]		0.0920[c]
passengers			(12.59)		(2.77)
Air transport,				0.3692[c]	
registered freight				(5.60)	
Error-correction	–0.0386	–0.0535	–0.0883	–0.0447	–0.1210[c]
term	(–2.42)	(–2.80)	(–2.24)	(–1.97)	(–2.04)
No. of observation	297	280	302	308	293

[a] = significance at the 1% level
[c] = significance at the 10% level.
Numbers in parentheses are t-statistics.

For ICT infrastructure, a 10% increase of the number of telephone lines and mobile phones increases economic growth more than 1%. In the era of globalization, information spreads faster through the internet. Thus, quality ICT infrastructure enables consumers, producers, businesses, and politicians to obtain knowledge and information, which can be referred to as growth enhancement. From the results in column 3, an increase of 10% of internet facilities increases growth by 2%.

Columns 4, 5, and 6 report the results of infrastructure in the energy sector. Power consumption has a positive relationship with economic growth. For quality, an electric power transmission and distribution loss is negative and statistically significant. Reducing transmission and distribution losses by 1.0% increases growth by 1.1%. The importance of electricity on economic growth has been widely discussed since Kraft and Kraft (1978). Having a reliable electricity supply is crucial for growth, as electricity is an essential input, and any shortages or deficient can significantly reduce output. Another proxy for energy infrastructure (e.g., use of alternative or nuclear energy) is positive, but the result is not significant.

Table 12: Infrastructure Effects on Economic Growth

	Information and Communications Technology Infrastructure			Energy Infrastructure		
	(1)	(2)	(3)	(4)	(5)	(6)
Population growth	0.0166	–0.2390	1.1350	0.1920	–0.5020[c]	–0.0110
	(0.66)	(–1.59)	(1.53)	(0.74)	(–4.30)	(–0.11)
Investment	–0.1948	0.8130[c]	1.2370[c]	1.2600[c]	0.2380[b]	–1.4060
	(–1.31)	(4.31)	(2.19)	(2.09)	(1.81)	(–3.65)
Trade openness	0.8044[c]	0.3850[c]	1.0580[c]	0.4370[c]	0.4860[c]	0.7006
	(11.59)	(3.08)	(2.20)	(2.20)	(4.29)	(3.83)
Human capital		0.7720[c]	1.0260[c]	–0.4820		
		(3.40)	(4.52)	(–0.10)		
Telephones	0.2568[c]					
	(8.71)					
Mobile phones		0.1130[c]				
		(4.45)				
Internet users			0.2180[c]			
			(4.89)			
Electric power consumption				0.7450[c]		
				(6.33)		
Alternative and nuclear energy					–0.0140	
					(–0.61)	
Electric power transmission and distribution losses						–1.1200[c]
						(–5.27)
Error-correction term	–0.0378	–0.0790[b]	–0.0130	–0.0200	–0.1080[c]	0016
	(–1.01)	(–1.86)	(–0.52)	(–0.82)	(–2.36)	(0.11)
No. of observation	295	145	145	145	146	299

[b] = significance at the 5% level,
[c] = significance at the 10% level.
Numbers in parentheses are t-statistics.

6. SUMMARY AND CONCLUSION

Facilitating trade not only requires efficient hard infrastructure, but also soft infrastructure elements such as a good business and regulatory environment, transparency, and customs management. This study shows that improvement in all transport infrastructure sectors results in an increase in trade flows. Second, the role of ICT infrastructure plays a vital role in trade enhancement, and applies both exporters and importers. Third, although more attention has been given to hard infrastructure, the need to examine the impact of soft infrastructure on trade flows is key today.

The study identifies air transport, road transport, and port and container facilities in agricultural and manufacturing exports as confirming the results from aggregate trade data. For ICT infrastructure, telephone lines and internet security are found to be significant. Finally, reduction in documents is important for agricultural exports, and reduction in cost to export and time to export is vital to manufacturing exports.

The quality of infrastructure is as important as the quantity; any inadequate or poorly performing infrastructure may create obstacles for economies to meet their full growth potential. Results confirm that the quantity of infrastructure is important to enhance economic growth; however, having quality infrastructure benefits more in producing productive and efficient output, thus has greater impacts on sustainability in economic growth.

As markets are integrating more, the role of infrastructure should be important. Economies that still score low in regard to physical infrastructure should invest more in road density, rail, and port facilities to facilitate doing business. ICT infrastructure, especially basic infrastructure such as telephone lines, broadband access, and internet security, should also be emphasized for communication benefits and to ease financial transactions between trading partners.

In the future, energy and financial infrastructure should be studied as to their impact on growth. More soft infrastructure variable indicators should be included in analyses, as well, to enhance understanding of its impact on trade flows.

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