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The Economic Impact of Enhanced Multimodal Connectivity in the APEC Region

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HIGHLIGHTS

Performance of individual transport modes and logistics, as well as overall multimodal transport performance, have a robust and significant association with stronger trade relations.

- The empirical analysis covers air, land, and maritime transport, as well as logistics performance as a proxy for an economy's ability to manage complex multimodal linkages. It also uses an aggregate index of multimodal performance, which is a weighted average of the air, land, maritime, and logistics indicators.

- For total trade—i.e., all products added together—all individual transport modes, as well as logistics competence, are associated with stronger bilateral trade links. The association is highly statistically significant in all cases. The closest relationship with trade is for logistics competence: improving an economy's performance by one percentage point relative to the regional leader is associated with an export increase of over 2%. A weakly performing logistics sector represents the most important chokepoint in terms of supply chain performance and multimodal transport connectivity.

- The numbers are smaller, but still important, for the individual transport modes. The effect of maritime transport is around half as strong as that of logistics competence. A one point increase in the maritime transport index is associated with a trade increase of just over 1%. Next in line comes air transport, with an effect just slightly weaker than that of maritime transport. Land transport has the weakest effect, with a one point increase in the index being associated with a 0.5% increase in trade. This result makes sense in light of the fact that land transport is most important for movement of goods within economies, rather than between them.

The way in which individual transport modes and the logistics environment interact can give rise to economic benefits in which the whole is greater than the sum of the parts.

- Similar results are obtained using our overall multimodal transport connectivity indicator. The impact of multimodal transport on trade flows is positive and highly statistically significant. A one percentage point improvement in performance is associated with a nearly 3% increase in exports as a unilateral impact, and before accounting for reallocation effects across economies. This effect is stronger than for any of the component indices on their own. When the possibility of a "virtuous cycle" between multimodal performance is accounted for, the effect is weaker but still statistically significant.

The trade gains from improving multimodal transport performance can be substantial.

- "What if" exercises based on gravity model estimates show that an improvement in overall multimodal performance would significantly boost exports. Taking into account the "virtuous cycle" between multimodal transport performance and trade as well as the complex reallocations of exports that occur when economies reform simultaneously, the counterfactual simulations show that a 5% improvement in overall multimodal performance would increase exports to the world by nearly $500bn annually or an increase of 4%. The range for individual member economies is between 2% and 6% of baseline exports. In dollar terms, this equates to an impact gain of between $850m and $115bn per member economy.

- High performers in multimodal transport have the most to gain: 5% improvements in these economies represent substantial performance upgrades. Economies with challenging multimodal transport environments see smaller, but still significant, gains from reform: at a minimum, an increase in exports of nearly 2% follows concerted reforms that improve multimodal transport performance by 5%. Another feature of the simulation results is that relatively small and open economies stand to realize significant gains from reform.

The impact of individual transport modes and overall multimodal performance varies across sectors.

- Trade in consumer goods is the most sensitive to improvements in overall multimodal transport connectivity. Capital goods, transport equipment, other goods, and industrial supplies follow. Weak multimodal transport connectivity therefore represents a significant chokepoint in these sectors.

- Maritime transport plays an important role as a potential chokepoint in exports of consumer goods, capital goods, and industrial supplies.

- Air transport is especially important for exports of food, and to a lesser extent consumer and other goods, and industrial products.

- Land transport appears to be the most important chokepoint for exports of transport equipment.

- The most consistent results from any of the four indicators come from logistics competence. It is a significant determinant of trade performance in all sectors. This finding highlights the importance of making all transport modes work together through an efficient logistics sector.

- Logistics performance is most important for other goods, followed by food and beverages, capital goods, consumer goods, transport equipment, and industrial supplies.

There is considerable scope for policymakers in member economies to help reduce the incidence of supply chain bottlenecks, and boost trade.

- Investing in trade- and transport-related infrastructure development and maintenance should remain a crucial priority for member economies. Working together on a regional or sub-regional basis may be appropriate in some cases, for example transit corridors.

- A supportive regulatory environment can help promote better multimodal transport connectivity and supply chain performance. Regulatory reform based on cost-benefit analysis can help increase connectivity, as well as the quality of service provision in vital areas such as logistics.

- The private sector should be a key participant and partner in infrastructure development and regulatory reform. Development of private sector competence in areas such as logistics should also remain a key priority for member economies, as part of a more general program of private sector development.

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1. INTRODUCTION

A. BACKGROUND AND SCOPE

APEC has identified underdeveloped multimodal transport capabilities as one of the priority chokepoints to be addressed under the Supply Chain Connectivity Framework.[1] To help economies understand further how multimodal links are vital to the connectivity of modern supply chains and trade, the APEC Committee on Trade and Investment (CTI) tasked the Policy Support Unit (PSU) to undertake a study to quantify how enhanced and efficient multimodal connectivity could contribute to economic integration and the competitiveness of the region. Specifically, the study will examine the following:

- What are the chokepoints that impede multimodal connectivity in the Asia Pacific region today?
- What is the potential economic impact of increased multimodal connectivity on the Asia-Pacific region in terms of economic growth, trade and investment flows, and regional economic integration?
- What data is available to support the analysis and what empirical work has already been undertaken within and across APEC economies?
- Propose actions to holistically address and unblock these chokepoints.

The focus of new empirical work done for this study is on the potential impact on trade. Earlier studies that have discussed and/or provided estimates of the benefits to the APEC region from improved transport and supply chain connectivity are cited.

The principal limitation of this study relates to measurement. Multimodal transport connectivity is a complex concept. It involves the quality and quantity of infrastructure, as well as the private sector's ability to coordinate complex intermodal linkages. Our data capture those three dimensions by including information on land, air, and sea transport, in addition to logistics competence as a proxy for an economy's ability to manage intermodal connections along the supply chain. Our approach represents the first comprehensive effort to measure multimodal transport connectivity, and is a sound basis for future work to expand on our research and results.

Ideally, however, connectivity would also account for network effects, such as the importance of being connected to other economies that are themselves well connected. For instance, a strong air connection with a major hub such as the United States is clearly a major asset in terms of connectivity. The same point applies to a direct maritime link with Singapore, or a well-maintained international highway that enables access to a major, and well-connected market. These effects are particularly important for small but well-connected economies that act as regional and global transport hubs.

Data for capturing these types of network effects are currently scarce, and methodologies to exploit them are still under development. For that reason, the approach taken here represents the most robust possible approach to connectivity given the current state of the data. As new data and methods become available, it can be extended to more fully account for network interactions.

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[1] A conclusion from the APEC Supply Chain Connectivity Symposium held in May 2009.

B. DIRECT AND INDIRECT IMPACTS

Multimodal connectivity includes individual modes of transport (air, sea, and land) as well as the intermodal linkages. As such, it entails a network of links (such as the roadways, railways and transport routes) and nodes (facilities such as marine ports and airports). According to Battaglia (2007), a holistic view of transportation in which individual transportation modes work together or within their own niches is a useful way to understand the concept of intermodalism.

Improvements in multimodal connectivity are immediately enjoyed by the direct users. The potential benefits to shippers are explained by Jacoby and Hodge (2008). For example, when new transportation infrastructure is built companies take advantage by adjusting their logistics processes and supply chains. They change purchasing and operations behavior in the short-run, while in the longer term they make input substitutions and reconfigure production processes to take advantage of transportation system improvements, thereby improving service and reducing costs. The potential to reduce a company's operating costs arise from lower sourcing costs; reduced fleet, warehousing and inventory costs; and from improved transit time visibility.

The economy-wide impact captures the spillover or other related multiplier effects from the transportation and supply chain benefits. Expansion of a transportation network, as a result of multimodal connectivity brings better linkages to supplies, inputs and final goods thereby improving the efficiency of global supply chain in production. Improved logistics and supply chains could open up access to previously unreachable areas as well as link key economic centers in a region to national markets. The economy-wide benefits could include the following:

Trade expansion and larger foreign direct investments: Transportation and logistics improvements are critical to trade flows and the competitiveness of an economy's exports and imports. Each day saved is equivalent to an average *ad valorem* tariff reduction of between approximately 0.4 and 1% for export and 0.8 and 1.5% for import.[2] (Hummels et al, 2007: 9). In addition, an increase in competitiveness could attract additional FDI. For manufacturers, more efficient transport links mean factories can take advantage of cheaper land and labor in the country's interior. International companies are also discovering that there are clusters of complementary businesses emerging inland that they can tap into. A study by MIGA (2003) concluded that one of the strengths of Thailand in attracting FDI is the good transportation and logistics infrastructure for electronics manufacturers, which is crucial for just-in-time electronics assembly operations.

Industrial impact: More trade and investments could foster growth in other industrial sectors such as tourism, manufacturing and retail. Carruthers et al (2003) noted that improved logistics can foster faster progress in industrialization because as countries move from resource extraction to sophisticated manufacturing, they must also develop their logistics capabilities accordingly. Improved logistics will also enable more efficient (global and regional) production networks. In turn this will result in more employment in positively affected industries/sectors through forward and backward linkages.

[2] The per-day value of time savings for export and imports will be different depending on the product composition (of the related exports and imports).

Regional Integration: Better transport and logistics support stronger regional integration. World Bank (2009a: 18) argues that falling transport costs have coincided with greater economic concentration within countries and have caused trade with neighbors to become even more important. This occurs because of the growing importance of scale economies in production and transport. Guerrero et al (2009) argue that one explanation for why Latin American and the Caribbean (LAC) countries have lagged in their integration into the world trading system is their inability to cope with a globalization process that is inherently transport intensive and where supply chains are now being organized on a global scale.

Development and poverty reduction: Basic foodstuffs, as well as agricultural inputs like fertilizers, and development products like medicines, all need to be moved quickly and cost-effectively in order to promote human development aims. Better transportation logistics enables faster deliveries of goods and services as well as a reduction in consumer prices. Transport infrastructure also provides rural areas with access to greater participation in development opportunities that leads to a more balanced spatial development. Adequate logistics access will promote rural entrepreneurship and trade (UNESCAP 2008). However, as questioned by Bafoil (2010) in analyzing the situations in the Central and Eastern Europe and the Great Mekong sub-region, transport infrastructure does not link to regional development by itself. Under certain conditions, infrastructure could also deepen the territorial inequalities and increase the relative poverty, or sometimes absolute poverty, by marginalizing the poor further because of unequal distribution of the fruits of development.

Other Benefits:

- *Foster economic diversification:* Improved logistics encourages greater variety in production by directly lowering the fixed costs of expansion and by lowering the marginal costs of serving markets (Carruthers et al 2003).

- *Decreased environmental hazards:* Better transportation infrastructure facilities in terms of environmental safety and standards could reduce the risk of environmental calamities. In addition, the removal of congestions that existed previously could potentially reduce air pollution through a more energy efficient transportation logistics system.[3]

The economy-wide impact of improved multimodal connectivity will mostly be realized in the medium to long-run. The potential economic gains through the opening of wider trade access will depend on the changing patterns of flows of goods, services, and factors of production. Moreover, the distribution of these benefits will depend on the linkages and the integration level between the overall international supply chain and transport logistics network. For the case of an infrastructure project, size is not directly related with the economic impact that the project will have. As Vickerman (2007: 13) noted: "…it is not the size of the infrastructure project, which determines the scale of the wider economic benefits. Large projects are likely to have a wider impact in terms of greater direct user benefits, but the wider benefits are not simply proportional to the direct user benefits. Some relatively minor projects, the 'unlocking' projects, can have disproportionately large wider benefits,

[3] The realization of this benefit, however, must be accompanied by stringent emission standards targeted at vessels, cargo handling equipment, locomotives, road vehicles or other modes of transport.

whereas some very large projects may have relatively little impact on the key scale, productivity and linkage effects."

A study commissioned by the APEC Policy Support Unit (2009:126) used a general equilibrium model to assess the potential gains from a 1% increased productivity of the transport sector in APEC economies. The increase in productivity has two key effects. First, it lowers the cost of distributing inputs and outputs (thus lowering their price). Second, it increases income and therefore increases the demand for goods and services. This increase in the level of goods and services demanded is offset, at least in part, by the reduction in the cost of delivering goods. The simulations were restricted to those APEC economies with relatively large transport sectors. In the developing economies, the combined effects of income growth and falling prices is substantial in Chile; China; Peru;, the Philippines; and Thailand – with income growth ranging from 7% for Chile to 2% in Peru, with average price falls of 2%. In the industrialized economies with extensive transport systems, income growth ranges from 1.3% in the US to 3.1% in Japan while price falls between 0.4 to 1.3%.

A report prepared for the APEC Supply Chain Symposium held in May 2009 (TheCIE 2009: 6-7) used a general equilibrium model to estimate the gains from improving supply-chain connectivity in the region. The impact of a 10% improvement in the efficiency of transporting goods between the borders of APEC economies[4] is estimated to be over US$21 billion (in 2004 real dollars) with Thailand and Viet Nam having the largest relative gain in terms of per cent change in real GDP. Captured in this simulation are some benefits from improvements at-the-border, such as in customs documentation and administration as well as in port handling.

C. BARRIERS TO CONNECTIVITY

As discussed by Prentice (2003), ideally each mode of transport is used for the length of the haul that minimizes the line haul cost for the maximum distance moved such that the best attributes of each mode are combined yielding the lowest cost of transportation for the supply chain. Although efficiency is a prime consideration, accessibility is a further reason for using two or more modes of transport. Moreover, intermodal transportation systems compete in terms of cost and time. For shippers of value-added goods for example, reliability and transit time are as important as freight rates in modal choice decisions. Reliability and transit time can be affected by the level of connectivity. For maximum connectivity of intermodal transport, the absence of bottlenecks is required: a supply chain is only as strong as its weakest link. A bottleneck is any impediment that slows or halts the flow of traffic.

Prentice (2003) classifies the causes of bottlenecks under three general categories, namely: infrastructure bottlenecks, regulatory bottlenecks, and supply chain dysfunctions. Infrastructure problems could be chronic or temporary in nature. Chronic infrastructure bottlenecks can be due to climate and physical barriers or due to underinvestment. There are also temporary infrastructure bottlenecks which could arise from weather disruptions, market perturbations (e.g. temporary surge in demand), and disinvestments (i.e. when parts of infrastructure are abandoned or maintained at a lower level of efficiency). Regulatory bottlenecks are described as unintended consequences of some other policy objective and these could be direct effects (e.g. safety/quality inspections and security measures) and

[4] Brunei Darussalam and Papua New Guinea are not included.

indirect effects (e.g. cabotage restrictions). Finally, another source of bottlenecks could be due to dysfunctional supply chains which occur when participants fail to act in a common interest, for example with respect to hours of operation. Congestion and queues are symptoms of bottlenecks and careful analysis is needed in removing the bottleneck. The solution is not necessarily the expansion of infrastructure especially if the problem is regulatory in nature. Additionally, the author notes that some parties may benefit from bottlenecks and may not want them removed. Thus, infrastructure solutions are not proposed to solve 'gatekeeper" problems.

Goh et al (2008) offer a similar taxonomy, which distinguish between regulatory and non-regulatory barriers to the integration of multimodal transport networks. Regulatory barriers can arise from the cost of exchange at interface (i.e., customs-related barriers) and from cabotage (i.e., restrictions on domestic transport of freight within a foreign country). Non-regulatory barriers can arise due to lack of infrastructure by country or by mode (e.g., road, rail, maritime and air transport infrastructure) as well as from lack of inter-connectivity between modes of transport.

Some of the key issues and challenges facing the transport sector in individual APEC economies are presented in Annex A. Although specific bottlenecks and priorities for action vary among economies there seem to be some common issues that affect the achievement of multimodal connectivity.

For one, the problem of underinvestment in infrastructure is not confined to developing APEC members as this is an issue even in industrialized economies. However, it is recognized that while under-investing leads to congestion; over-investing will lead to wastage. As such, efficient use and maintenance of existing assets require attention too. Related to infrastructure provision is the need for a strategic approach to infrastructure development. Again, in both developed and developing economies, the business sector in particular stressed that transport infrastructure planning be more closely linked with trade and other policies (e.g. land use, tax, foreign investment, etc.). More specifically, a supply chain approach to infrastructure development is seen by industry as a missing element. Failure to have an economy-wide approach and consideration for whole-of-supply chain requirements lead to either under-provision or under-utilization of transport infrastructure. Thus, while inadequacy of infrastructure investment is a constraint, inefficiency of investment is as crucial.

Another difficulty revolves around the sharing of costs and benefits among stakeholders or affected parties. Even when there is agreement on the overall benefits of fixing a particular bottleneck, the lack of understanding and mechanism to share both the risks and rewards work against achieving multimodal connectivity. The result is that critical projects do not get implemented or facilitation arrangements are slow to get off the ground.

Regulatory frameworks governing the various transport sectors could hinder the achievement of multimodal connectivity as well. Access regulations and price signals which distort modal choices and utilization are seen as key impediments to the development of optimal multimodal transport networks. One area, for example, is the need to ensure a level playing field between modes (i.e. between road and rail).

Last but not the least, the quality of service is a subject that has been highlighted. Behind this are concerns about inefficient service providers as well the shortage of required skills (both existing and forecasted), which could hamper the development and growth of the various transport and logistics industries.

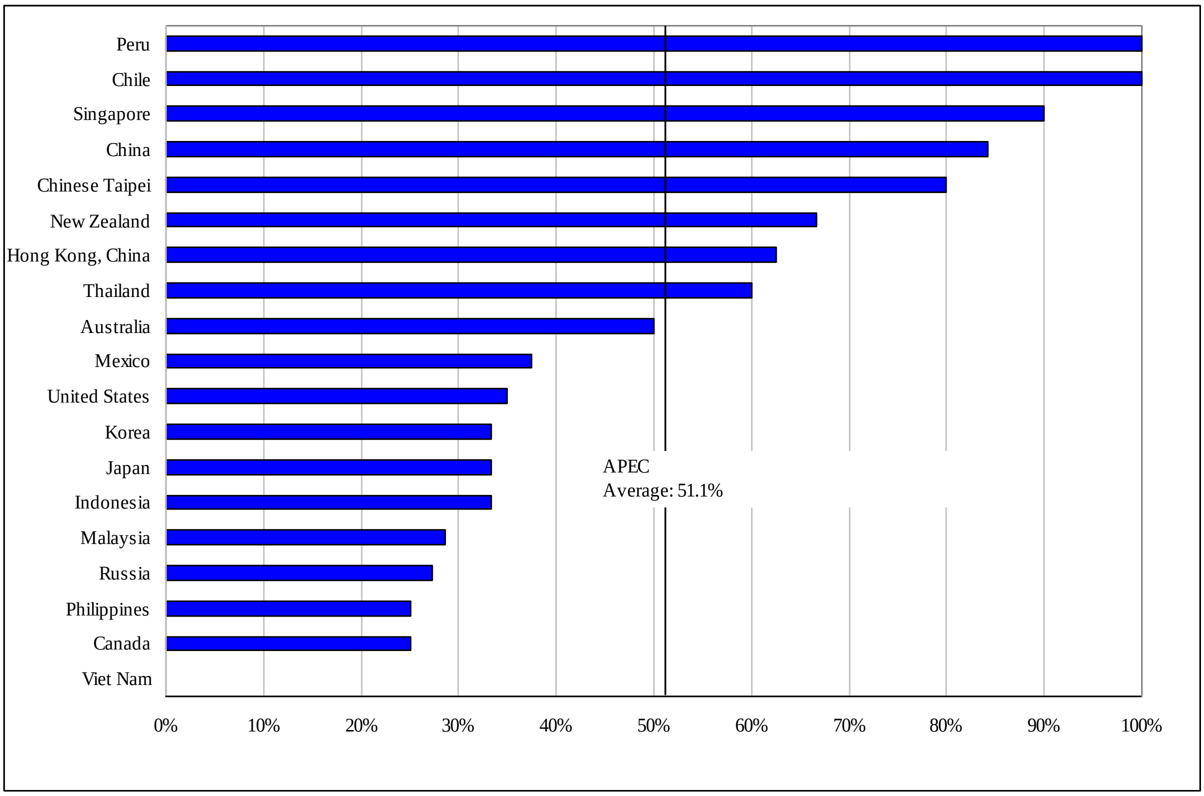
The range of issues which affect multimodal connectivity discussed above is not exhaustive but draws attention to those that seem to resonate regardless of income group or stage of development.

2. OVERVIEW OF MULTIMODAL CONNECTIVITY IN THE APEC REGION

In achieving efficient costs for transport and logistics, an optimal combination of "modal mix" is desirable. In making decisions to transport certain goods from point A to point B, the choice will be based on several options available in terms of routes as well as the optimal and balanced "transportation mix" based on the available transport infrastructure; considerations of time, costs and risks are essential for any logistics decisions. In that sense, it is necessary to view the available modes of transport in a coherent and holistic manner – within a framework of the supply chain. This chapter provides a general picture of multimodal transport connectivity in the APEC region based on both quantitative and qualitative measures.

According to the latest Logistics Performance survey conducted by the World Bank (2010a), trade and transport infrastructure have improved since 2005 in 18 economies.[5] Moreover, the positive assessment was unanimous among the survey respondents in two Latin American economies, Peru and Chile. (See Figure 1) This means that economies with difficult transport and logistics environments are actively engaged in a process of gradual catch-up, even though considerable challenges still remain.

Figure 1 Trade and transport infrastructure improved or much improved since 2005, percentage of LPI Survey respondents

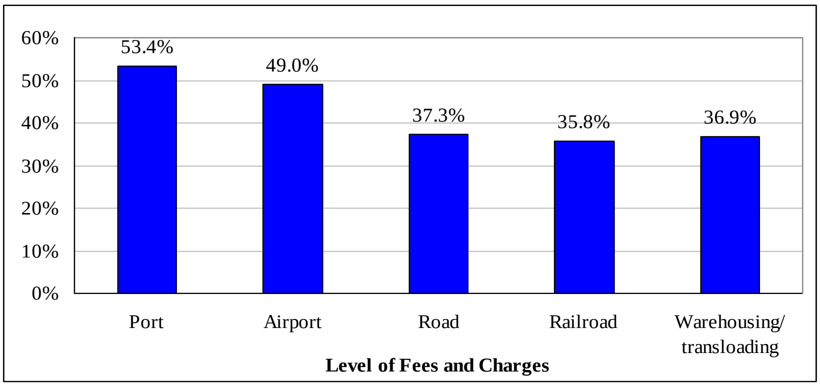


Source: World Bank (2010a).

[5] Brunei Darussalam and Papua New Guinea are not covered in this part (i.e. domestic logistics performance) of the survey. The APEC average is a simple average across 19 economies.

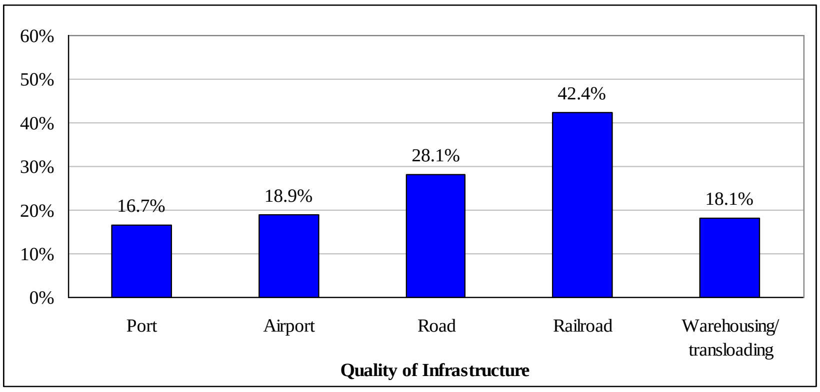
Across the sectors, maritime has the highest level of dissatisfaction in terms of fees and charges while railroads have the highest level of dissatisfaction with respect to the quality of infrastructure. It also has the lowest level of satisfaction in terms of the competence and quality of services. (See Figure 2, Figure 3, and Figure 4)

Figure 2 Percent of respondents answering that "Fees and charges are high/very high"[6]



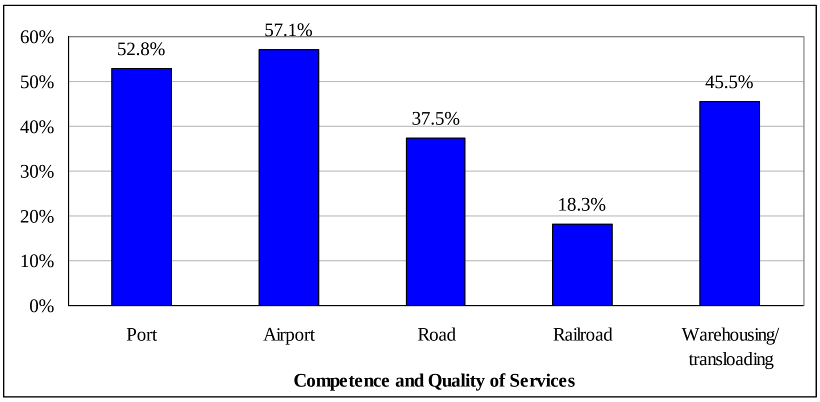
Source: World Bank (2010a).

Figure 3 Percent of respondents answering that "Quality of infrastructure is low/very low"



Source: World Bank (2010a)

Figure 4 Percent of respondents answering that "Competence and quality of services is high/very high"



Source: World Bank (2010a).

6 Simple averages across APEC economies covered by the survey are presented from Figure 2 to Figure 4.

A. MARITIME

UNCTAD's Liner Shipping Connectivity Index[7] (LSCI) aims at capturing how well economies are connected to global shipping networks. The higher the index value, the easier it is to access a high capacity and high frequency global maritime freight transport system and thus effectively participate in international trade. China; Hong Kong, China; and Singapore are among the top three, followed by Korea; United States; and Malaysia. (See Table 1)

Table 1 Liner Shipping Connectivity Index (LSCI), 2004–2009

Economy	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Rank**	**Change 09/04**
China	100.00	108.29	113.10	127.85	137.38	132.47	1	32.47
Hong Kong, China	94.42	96.78	99.31	106.20	108.78	104.47	2	10.05
Singapore	81.87	83.87	86.11	87.53	94.47	99.47	3	17.60
Korea, Rep.	68.68	73.03	71.92	77.19	76.40	86.67	5	18.00
United States	83.30	87.62	85.80	83.68	82.45	82.43	9	-0.87
Malaysia	62.83	64.97	69.20	81.58	77.60	81.21	10	18.38
Japan	69.15	66.73	64.54	62.73	66.63	66.33	14	-2.82
Chinese Taipei	59.56	63.74	65.64	62.43	62.58	60.90	15	1.34
Canada	39.67	39.81	36.32	34.40	34.28	41.34	21	1.68
Thailand	31.01	31.92	33.89	35.31	36.48	36.78	25	5.77
Mexico	25.29	25.49	29.78	30.98	31.17	31.89	31	6.60
Australia	26.58	28.02	26.96	26.77	38.21	28.80	36	2.22
Viet Nam	12.86	14.30	15.14	17.59	18.73	26.39	39	13.53
Indonesia	25.88	28.84	25.84	26.27	24.85	25.68	41	-0.20
Russia	11.90	12.72	12.81	14.06	15.31	20.64	48	8.73
Chile	15.48	15.53	16.10	17.49	17.42	18.84	56	3.36
Peru	14.79	14.95	16.33	16.90	17.38	16.96	60	2.17
Philippines	15.45	15.87	16.48	18.42	30.26	15.90	61	0.45
New Zealand	20.88	20.58	20.71	20.60	20.48	10.59	79	-10.29
Papua New Guinea	6.97	6.40	4.67	6.86	6.92	6.58	105	-.039
Brunei Darussalam	3.91	3.46	3.26	3.70	3.68	3.94	134	0.03

Note: The order of economies is arranged by 2009 global rank.
Source: UNCTAD (2009a).

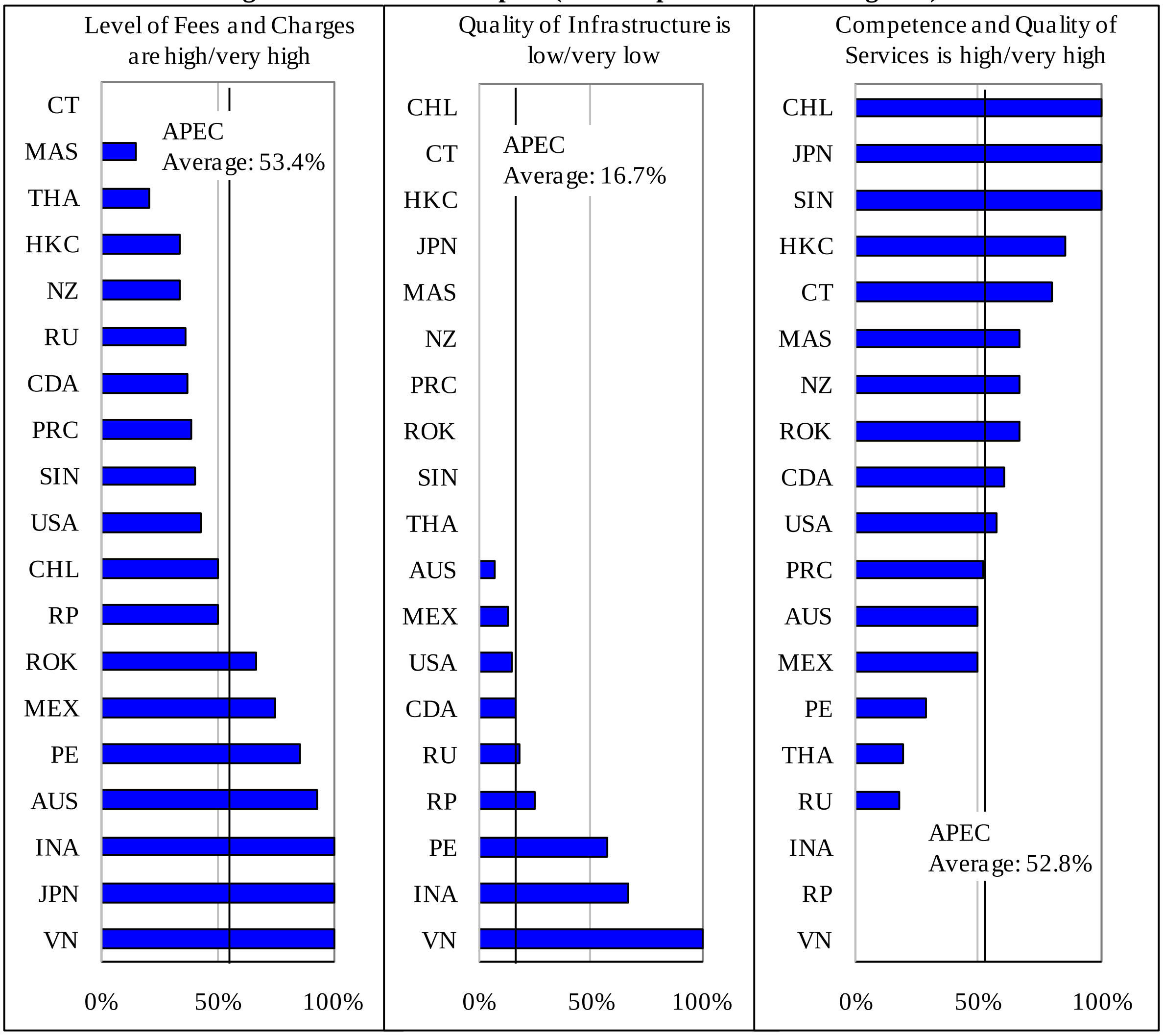
Among APEC economies, Korea and Malaysia have significantly improved their LSCI ranking since 2004. Korea has seen major port investments in Inchon and Pusan while Malaysia strengthened its position by providing liner companies with dedicated container

[7] The first version of the 2004 LSCI was introduced in *Transport Newsletter* No. 27, first Quarter 2005. The current version of the LSCI is generated from the five components: (a) number of ships; (b) the container-carrying capacity of those ships; (c) the maximum vessel size; (d) the number of services; and (e) the number of companies that deploy containerships on services from and to a country's ports. The data is derived from *Containerisation International Online*. The index is generated as follows: For each of the five components, a country's value is divided by the maximum value of that component in 2004, and for each country, the average of the five components is calculated. This average is then divided by the maximum average for 2004 and multiplied by 100. This way, the index generates the value 100 for the country with the highest average index of the five components in 2004." (UNCTAD 2009a, page 122)

terminals as well as creating an emphasis upon crane and vessel productivity (UNCTAD 2009b). The decline in New Zealand's score could be due to the trend for large container ships[8] to be committed to the major trade routes thus reducing the chances of being visited by larger ships. The largest vessels currently visiting New Zealand are around 4,100 TEU capacity but some ports are preparing for 6,100 TEU ships. There is debate about the costs of accommodating these ships and the duplication of this investment in competing ports (New Zealand Treasury 2009).

Based on the latest survey of logistics professionals working in each economy, port charges are considered to be high by all the respondents in Indonesia; Japan; and Viet Nam. Except in a few economies, the quality of port infrastructure is not considered low by the majority of respondents. Moreover, the competence and quality of maritime transport services is perceived to be high by the majority of the respondents in ten of the APEC economies surveyed. (See Figure 5)

Figure 5 Maritime Transport (% of respondents answering that)



Source: World Bank (2010a).

[8] The largest to date is the MSC Daniela which has a capacity of 13,800 TEUs (UNCTAD 2009a).

According to the same survey, delays in maritime transshipment are experienced often by the respondents in Canada (10.53%); China (5.26%); Indonesia (50%); Malaysia (16.67%); Mexico (25%); Peru (33.33%); Russia (45.45%); the United States (5.13%); and Viet Nam (100%).[9]

B. AIR

The CIA World Factbook provides internationally comparable data on the number of airports in member economies.[10] There are more than a thousand airports in the United States; Mexico; Canada; and Russia. Focusing on just primary and secondary airports,[11] the same economies joined by China and Australia each has more than a hundred airports. (See Table 2)

Table 2 Air Transport Infrastructure within APEC

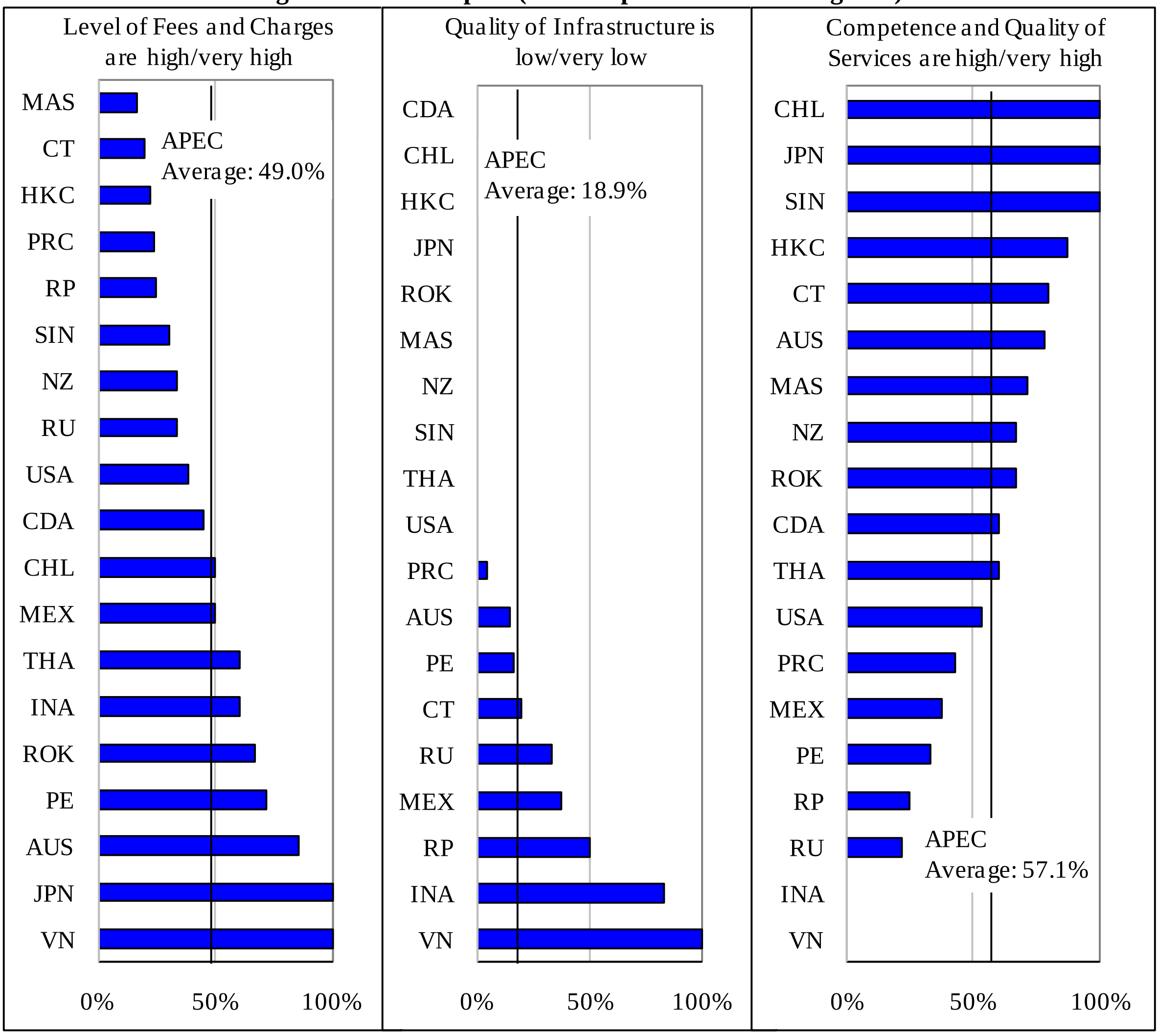
Economy	Total Number of Airports	Airports with paved runways	Primary Airports	Secondary Airports
Australia	464	325	24	145
Brunei Darussalam	2	2	1	0
Canada	1,388	515	37	148
Chile	357	81	13	22
China	482	425	195	133
Hong Kong, China	2	2	1	1
Indonesia	683	164	22	51
Japan	176	144	49	40
Korea, Rep.	116	72	25	13
Malaysia	118	38	17	6
Mexico	1,744	246	41	85
New Zealand	120	41	3	12
Papua New Guinea	560	21	2	14
Peru	201	57	26	14
Philippines	254	85	12	28
Russian Federation	1,216	595	250	129
Singapore	8	8	3	4
Chinese Taipei	42	38	16	11
Thailand	105	64	19	24
United States	15,095	5,174	419	1477
Viet Nam	44	37	14	14

Source: The CIA World Factbook 2009.

[9] Percent of respondents answering often or nearly always.
[10] For analytical purposes, it is important to have data that can easily be compared across economies. Other international data sources, such as the World Development Indicators, do not cover all member economies. This is why the CIA World Factbook is preferred in this case. Further, APEC TPT-WG (2007) also uses the same data source as in the present paper.
[11] Primary airports are regarded as those with paved runways of 2,400 meters or more (i.e. capable of supporting medium-large jet operations), while secondary airports are those with paved runways of 1,500 meters to 2,400 meters (i.e. capable of supporting smaller jets and turboprops) (APEC TPT-WG 2007: 14). These definitions are commonly used international benchmarks, but it could also be possible to apply alternative definitions that would result in different airport counts.

According to the survey of domestic logistics professionals, airport fees and charges are perceived to be high by all of the respondents in Viet Nam and Japan. Charges are also considered to be high in Australia; Peru; Korea; Indonesia; and Thailand, exceeding the APEC average. Similar to maritime, the quality of airports infrastructure is not considered low by the majority of respondents except in a couple of economies. With regard to the air transport services competence, there is also a high level of satisfaction in most economies (See Figure 6).

Figure 6 Air Transport (% of respondents answering that)



Source: World Bank (2010a).

With respect to air services, liberalization has been pursued under the auspices of APEC and other multilateral fora. APEC's Transportation Working Group (TPT-WG) developed the "Eight Options for More Competitive Air Services with Fair and Equitable Opportunity" (Eight Options) which identifies key areas to be addressed by APEC economies, including air carrier ownership and control, doing business matters, air freight, multiple airline designation, charter services, cooperative arrangements between airlines and market access.

A study commissioned by the APEC TPT-WG (2007) examined the extent to which the region and individual economies have moved towards targets set under the "Eight Options".

Air Services Agreements (ASAs) between APEC economies were analyzed to build a picture of the extent of achievement as of 2005. On the whole, it found that there have been highly uneven degrees of liberalization across individual economies. APEC members are moving toward more liberal provisions within their ASAs with each other, but with different speeds and priorities.

C. LAND

A number of APEC economies are connected by land thereby allowing alternative modes of transporting goods. Economies that share land borders are (The CIA World Factbook 2009):

- Brunei Darussalam and Malaysia – 381 km
- Canada and USA – 8,893 km (includes 2,477 km with Alaska)
- Chile and Peru – 171 km
- China and Hong Kong, China – 30 km
- China and Russia – (1) Russia southeast and China northeast - 3,605 km; (2) Russia south and China northwest - 40 km
- China and Viet Nam – 1,281 km
- Indonesia and Malaysia – 1,782 km
- Indonesia and Papua New Guinea – 820 km
- Malaysia and Thailand – 506 km
- Mexico and USA – 3,141 km

Singapore and Malaysia are connected by a causeway and second link.

Road

Table 3 features the key characteristics of the road network in APEC economies:

Table 3 Road Statistics for APEC Economies

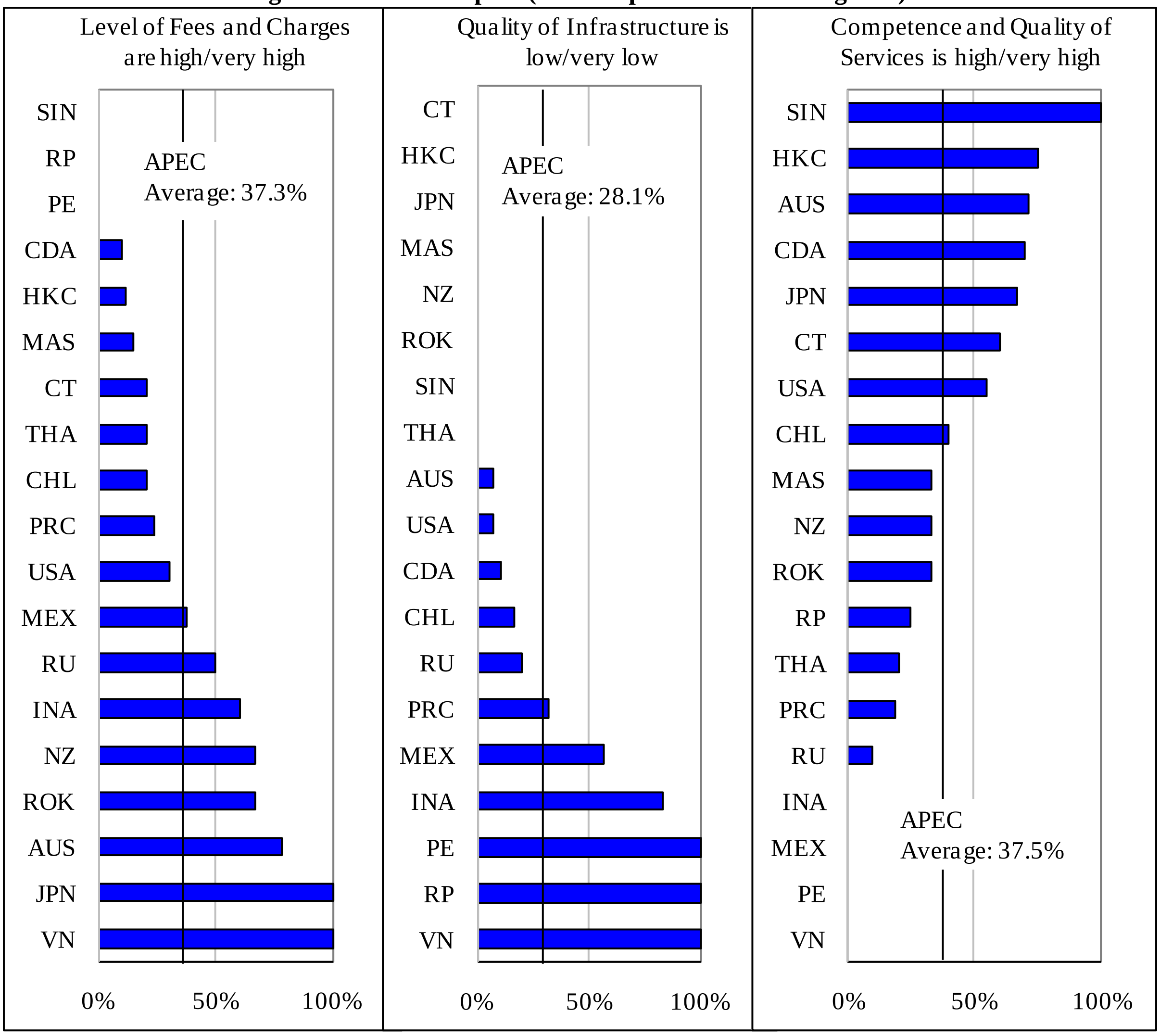
Economy	Year of data	Total Roadways (km)	Percentage of road paved	Road Service (Kilometers of road per 1,000 people)	Road Density (Kilometers of road per 1,000 sq km of land)
Australia	2004	812,972	42	38.23	105.82
Brunei Darussalam	2005	3,650	77	9.40	693.26
Canada	2006	1,042,300	40	31.13	114.62
Chile	2004	80,505	21	4.85	108.23
China	2005	1,930,544	82	1.44	201.73
Hong Kong, China	2008	2,040	100	0.29	1935.48
Indonesia	2005	391,009	55	1.63	215.84
Japan	2006	1,196,999	79	9.42	3284.08
Korea, Rep.	2008	103,029	78	2.12	1063.03
Malaysia	2004	98,721	81	3.84	300.38
Mexico	2006	356,945	50	3.21	183.62
New Zealand	2006	93,576	66	22.21	349.54
Papua New Guinea	2000	19,600	4	3.24	43.28
Peru	2004	78,829	14	2.67	61.59

Philippines	2008	201,910	11	2.06	677.16
Russian Federation	2006	933,000	81	6.66	56.97
Singapore	2007	3,297	100	0.71	4799.13
Chinese Taipei	2007	40,262	95	1.75	1248.05
Thailand	2006	180,053	n.a.	2.73	352.43
United States	2007	6,465,799	65	21.05	705.72
Viet Nam	2004	222,179	19	2.55	716.54

Note: Population used for the calculation of Road Service is estimates of July 2009.
Source: The CIA World Factbook 2009 and own calculation.

Based on the survey of domestic logistics professionals, many economies are considered having high road transport charges with the percentage of respondents in Russia; Indonesia; New Zealand; Korea; Australia; Japan; and Viet Nam exceeding the simple average percentage across the region. In six economies, the percentage of respondents who consider the quality of road infrastructure low is above the average for the region. In terms of the competence and quality of services, in seven economies the majority of the respondents consider it to be high. (See Figure 7)

Figure 7 Road Transport (% of respondents answering that)



Source: World Bank (2010a).

Rail

The United States has the longest rail network among APEC economies, followed by Russia; China; and Canada. (See Table 4)

Table 4 Rail Lines Statistics for APEC Economies

Economy	WDI, World Bank		The CIAWorld Factbook	
	Year of latest data	Rail lines (total route-km)	Year of data	Railways (km)
Australia	2007	9,639	2008	37,855
Brunei Darussalam	n.a.	0	n.a.	0
Canada	2007	57,042	2008	46,688
Chile	2007	6,008	2008	5,481
China	2007	63,637	2008	77,834
Hong Kong, China	n.a.	0	n.a.	0
Indonesia	1998	5,324	2008	8,529
Japan	2007	20,050	2008	23,506
Korea, Rep.	2007	3,399	2008	3,381
Malaysia	2007	1,667	2008	1,849
Mexico	2007	26,662	2008	17,516
New Zealand	1999	3,913	2008	4,128
Papua New Guinea	n.a.	0	n.a.	0
Peru	1997	1,691	2008	1,989
Philippines	2006	491	2008	897
Russian Federation	2007	84,158	2006	87,157
Singapore	n.a.	0	n.a.	0
Chinese Taipei	n.a.	n.a.	2007	1,588
Thailand	2006	4,044	2008	4,071
United States	2007	191,771	2007	226,427
Viet Nam	2007	3,147	2008	2,347

Source: World Bank, World Development Indicators Database; and the CIA World Factbook 2009.

One of the greatest infrastructure constraints for international rail flows is the different track gauge (i.e., the distance between the two rails) system adopted when constructing rail systems (Woodburn et al 2008). In Asia, for example, at least five different track gauges exist, ranging from metric in much of South East Asia up to 1.676m in the Indian sub-continent. Within APEC, China has generally adopted standard gauge track, while Russia has a broader 1.520m gauge. Chile has both broad and narrow gauge and Peru's railway is predominantly standard gauge. Canada; Mexico; and the US have standard gauge railways. Malaysia; Thailand; and Viet Nam have standard and narrow gauge railways but mostly the latter type. Indonesia adopts a narrow gauge only. (See Table 5)

Table 5 Rail gauges within APEC Economies

Economy	Railways Broad gauge	Railways Standard gauge	Railways Narrow gauge
Australia	142 km 1.600-m gauge	24,449 1.435-m gauge (1,094 km electrified)	13,304 km 1.067-m gauge (1,193 km electrified)

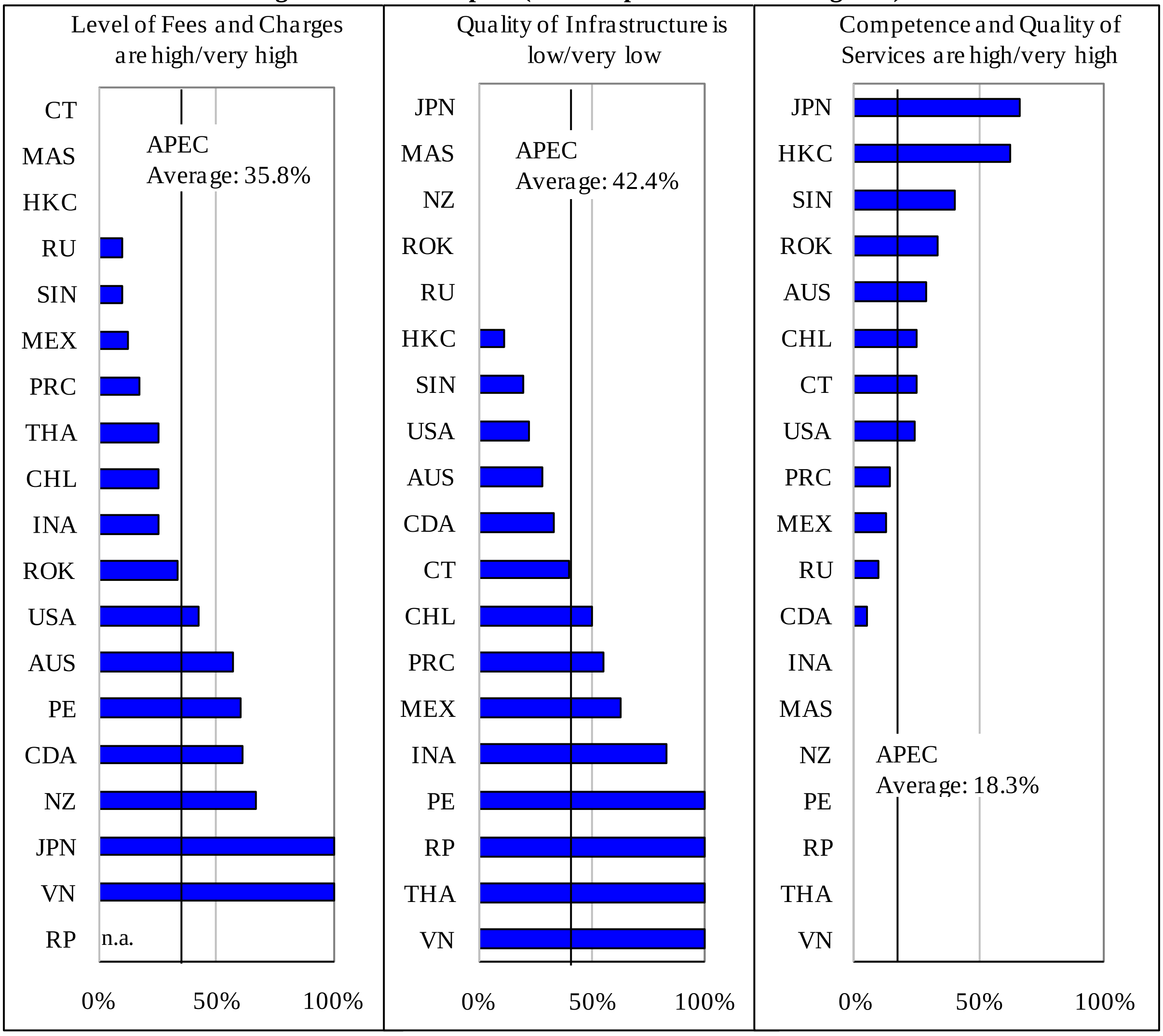
Brunei Darussalam	0	0	0
Canada	0	46,688 km 1.435-m gauge	0
Chile	1,706 km 1.676-m gauge (850 electrified)	0	3,777 km 1.000-m gauge
China	0	77,084 km 1.435-m gauge (24,433 km electrified)	750 km 0.750-m gauge
Hong Kong, China	0	0	0
Indonesia	0	0	8,529 km 1.067-m gauge (565 km electrified)
Japan	0	3,437 1.435-m gauge (3319 electrified)	20,059 km 1.067-m gauge (11,842 km electrified); 11 km 0.762-m gauge (11 km electrified)
Korea, Rep.	0	3,381 km 1.435-m gauge (1,843 km electrified)	0
Malaysia	0	57 km 1.435-m gauge (57 km electrified)	1,792 km 1.000-m gauge (150 km electrified)
Mexico	0	17,516 km 1.435-m gauge	0
New Zealand[12]	0	0	4,128 km 1.067-m gauge (506 km electrified)
Papua New Guinea	0	0	0
Peru	0	1,726 km 1.435-m gauge	263 km 0.914-m gauge
Philippines	0	0	897 km 1.067-m gauge (492 km are in operation)
Russian Federation	86,200 km 1.520-m gauge (40,300 km electrified)	0	957 km 1.067-m gauge (on Sakhalin Island). An additional 30,000 km of non-common carrier lines serve industries
Singapore	0	0	0
Chinese Taipei	0	345 km 1.435-m gauge	1,093 km 1.067-m gauge; 150 km .762-m gauge
Thailand	0	29 km 1.435-m gauge	4,042 km 1.000-m gauge
United States	0	226,427 km 1.435-m gauge	0
Viet Nam	0	178 km 1.435-m gauge	2,169 km 1.000-m gauge

Source: The CIA World Factbook 2009.

As mentioned earlier, rail transport seems to be the most neglected among the sectors. In terms of the quality of infrastructure and the competence and quality of services, the APEC average in this sector is not perceived as good as other modes. In at least four economies, there was unanimous assessment that the rail infrastructure is of low quality. Moreover, it was only in a couple of economies where majority of the respondents perceive competence and quality of rail services to be high. (See Figure 8)

[12] New Zealand adopted a narrow-gauge track due to its difficult topography and budget considerations. This has constrained the average speed of rail services (New Zealand Treasury, 2009).

Figure 8 Rail Transport (% of respondents answering that)

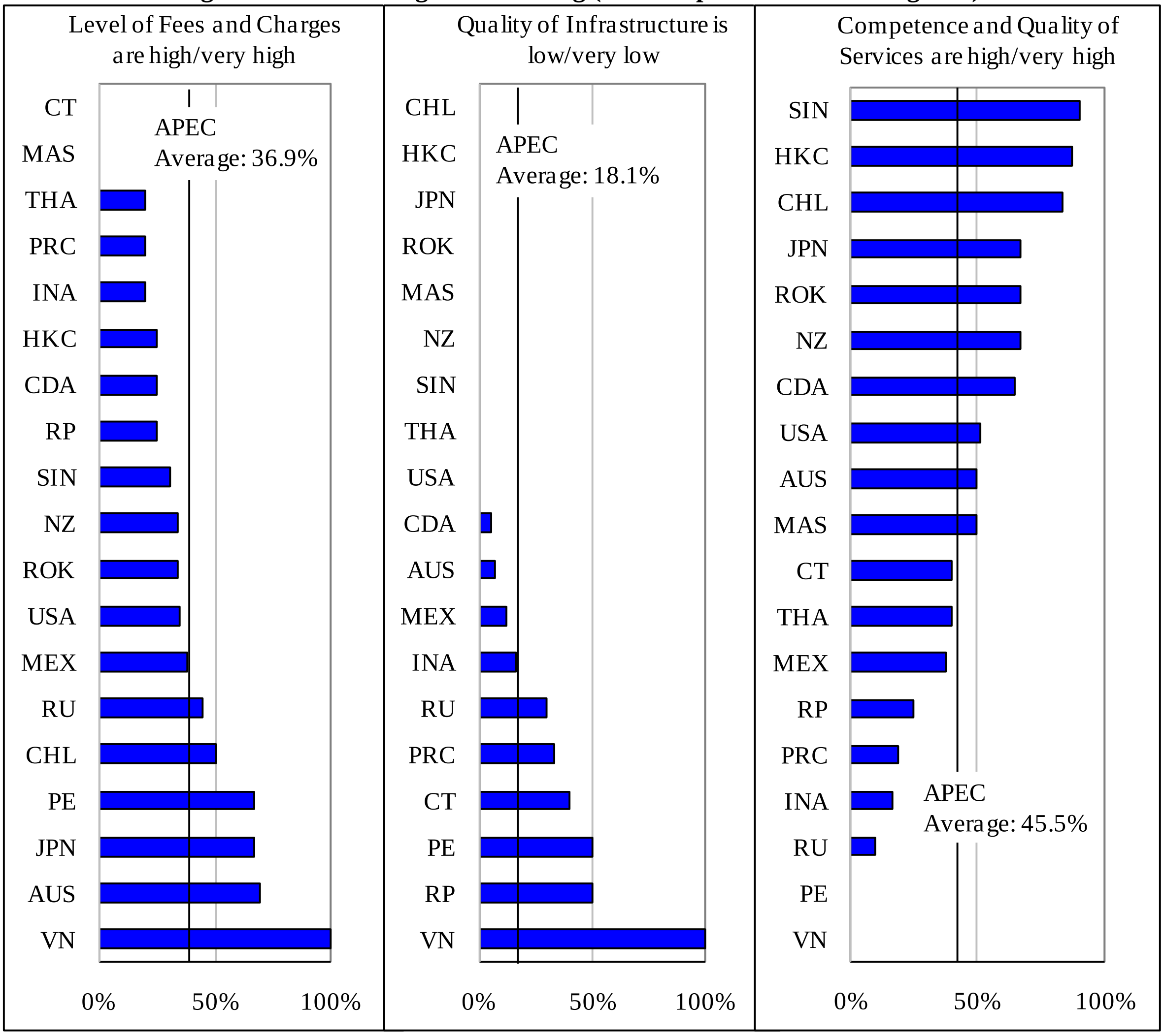


Source: World Bank (2010a). No result was reported for the Philippines in terms of "fees and charges".

D. INTERMODAL FACILITIES

Warehousing/transloading activities are integral to the seamless movement of goods between modes of transport. Warehousing/transloading charges are considered to be high by more than half of the survey respondents in Australia; Japan; and Peru and by all of the respondents in Viet Nam. The perception on the quality of warehousing/transloading facilities is generally favorable in the majority of APEC economies. The competence and quality of warehousing/transloading services is also considered high by at least half of the respondents in ten economies. (See Figure 9)

Figure 9 Warehousing/Transloading (% of respondents answering that)



Source: World Bank (2010a).

According to the same survey, delays due to compulsory warehousing/transloading are experienced often by respondents in Canada (5%); Indonesia (16.67%); Mexico (12.5%); Peru (33.33%); Russia (50%); Thailand (20%); US (5%); and Viet Nam (50%).[13]

E. LOGISTICS ENVIRONMENT

The private sector's ability to organize complex logistics activities as well as its capacity to make the individual transport modes work together depend on the overall logistics environment. The World Bank's Logistics Performance Index (LPI) summarizes the most important aspects of the logistics environment, which include: efficiency of the customs clearance process, quality of trade and transport-related infrastructure, ease of arranging competitively priced shipments, competence and quality of logistics services, ability to track and trace consignments, and frequency with which shipments reach the consignee within the scheduled or expected time.

[13] In parenthesis, percent of respondents answering often or nearly always.

The LPI uses a 5-point scale to assess performance. The average score for the APEC region is in the middle of this scale (3.38 in 2010). Since it is survey-based, the LPI is subject to sampling error. Thus, in comparing scores across economies and through time, the focus should be on statistically significant changes as indicated by *non overlapping low-high ranges* instead of simple comparisons of scores. Only when there is no overlap can it be concluded that there is a statistically significant difference between scores.[14] Using this criterion it can be gleaned from Table 6 that four APEC economies, namely: China; Mexico; Philippines; and Russia have improved from 2007 to 2010 in their logistics performance while the rest neither declined nor improved.

Table 6 Logistics Performance

Economy	2007			2010			Statistically significant difference
	Lower bound	LPI Score	Upper bound	Lower bound	LPI Score	Upper bound	
Australia	3.70	**3.79**	3.88	3.73	**3.84**	3.95	no change
Canada	3.87	**3.92**	3.97	3.78	**3.87**	3.97	no change
Chile	3.17	**3.25**	3.33	2.95	**3.09**	3.24	no change
China	3.28	**3.32**	3.36	3.45	**3.49**	3.53	improve
Hong Kong, China	3.96	**4.00**	4.04	3.78	**3.88**	3.98	no change
Indonesia	2.88	**3.01**	3.14	2.60	**2.76**	2.92	no change
Japan	3.99	**4.02**	4.05	3.91	**3.97**	4.03	no change
Korea, Rep.	3.45	**3.52**	3.59	3.57	**3.64**	3.70	no change
Malaysia	3.41	**3.48**	3.55	3.29	**3.44**	3.59	no change
Mexico	2.82	**2.87**	2.92	2.95	**3.05**	3.15	improve
New Zealand	3.63	**3.75**	3.87	3.22	**3.65**	4.08	no change
Papua New Guinea	2.14	**2.38**	2.62	2.21	**2.41**	2.62	no change
Peru	2.62	**2.77**	2.92	2.66	**2.80**	2.94	no change
Philippines	2.54	**2.69**	2.84	2.99	**3.14**	3.29	improve
Russian Federation	2.31	**2.37**	2.43	2.51	**2.61**	2.71	improve
Singapore	4.14	**4.19**	4.24	4.01	**4.09**	4.17	no change
Chinese Taipei	3.55	**3.64**	3.73	3.56	**3.71**	3.85	no change
Thailand	3.21	**3.31**	3.41	3.15	**3.29**	3.43	no change
United States	3.81	**3.84**	3.87	3.82	**3.86**	3.89	no change
Viet Nam	2.71	**2.89**	3.07	2.78	**2.96**	3.14	no change
APEC Average		**3.35**			**3.38**		

Source: World Bank (2007, 2010a).

[14] See Appendix 4 of Arvis et al. (2010) on the LPI methodology.

3. IMPACT OF ENHANCED MULTIMODAL CONNECTIVITY ON TRADE

A. MEASURING MULTIMODAL TRANSPORT CONNECTIVITY

The first stage in analyzing the relationship between APEC member economies' trade and their multimodal transport capabilities is to develop summary performance measures. This report is the first attempt to comprehensively assess and model the impact of multimodal transport connectivity within APEC. Work already exists on individual modes of transport, such as air (Geloso Grosso and Shepherd 2009), and previous work on trade facilitation in APEC includes indicators of the quality of air and maritime infrastructure (Wilson et al. 2004). In addition, Limao and Venables (2001) show more generally that infrastructure—an average of performance in road, rail, and telecommunications—is an important determinant of bilateral trade. This report extends this line of research by including air, land, and maritime links in a single modeling framework, and by showing the importance not just of modal performance, but of ensuring that all modes can work together within a sophisticated logistics framework.

Box: The Challenge of Measuring Transport Connectivity

Constructing multimodal transport indicators is a challenging task. Ideally, these sorts of indicators should combine data on the quantity and quality of transport facilities in each mode. Many different datasets are available that could potentially have something to add in assessing multimodal connectivity. Examples include: the *Global Competitiveness Report* (Wilson et al. 2005); the World Bank's *Logistics Performance Index* (Hoekman and Nicita 2008); and basic quantity indicators taken from the *World Development Indicators* and the *CIA World Factbook*. However, there is a tradeoff between constructing broad-based indicators, and ensuring that their coverage is wide enough to take account of the heterogeneity of APEC member economies. In the interests of ensuring maximum coverage, we have chosen to base our indicators on just a small number of data series in each case. Also, we use only international data sources because it is vital to use data that are comparable across economies in the econometric exercise.

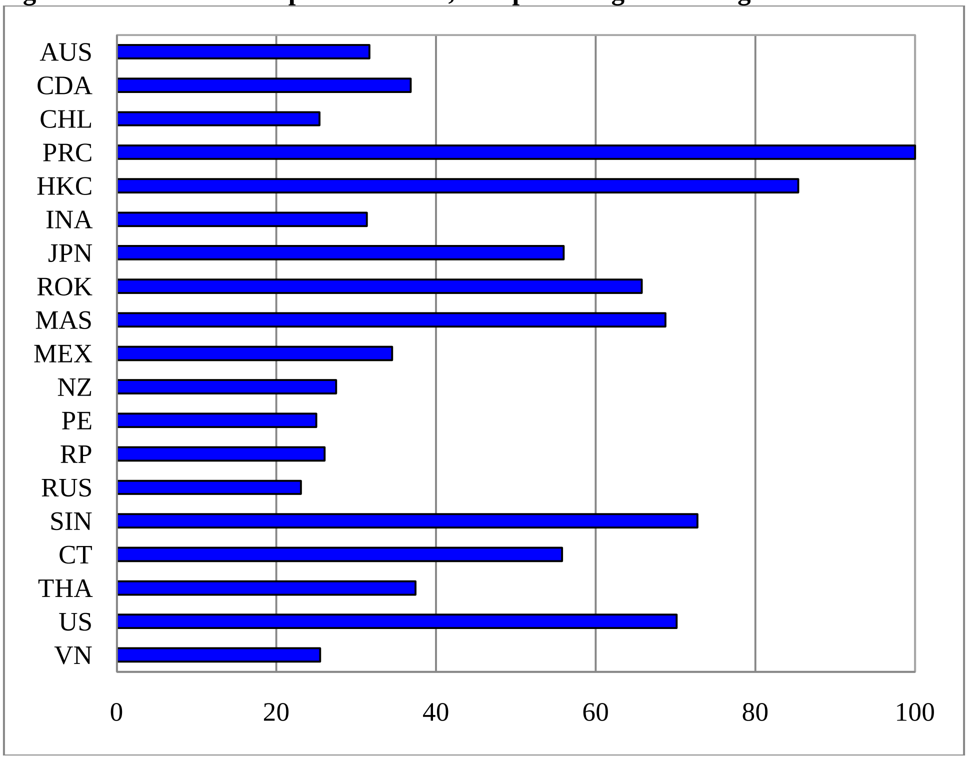
Another feature of connectivity that would ideally be included relates to network effects. In principle, a better connected economy is one that not only has more and better infrastructure, but also a greater number of direct links with major trading partners. Some small economies that act as regional transport and logistics hubs have very strong connectivity performance in this sense, and it may not be fully reflected in data on the quality and quantity of infrastructure.

Assessing connectivity in this way requires highly specialized data, however. To do it for road links requires detailed geographical information that needs to be specially prepared for each analysis; examples include Buys et al. (2006) for Africa, and Shepherd and Wilson (2007) for Europe and Central Asia. For air and maritime transport, timetable information on the frequency and extent of bilateral services is required. Ongoing work at the World Bank (Arvis and Shepherd Forthcoming) is examining the feasibility of constructing theory-based network connectivity measures using such data, but results are not yet available; IATA (2007) takes a more ad hoc approach. Future work on connectivity in the APEC context could make use of these kinds of indicators, but the present approach represents the best currently-available tradeoff between analytical rigor and data availability.

The remainder of this section examines the available data on multimodal transport connectivity. In each case, we use international data sources in order to ensure comparability of results across economies. This approach makes the econometric results as robust as possible. In presenting the data, we present each economy's score as a percentage of the score recorded by the regional leader. There are two reasons for presenting the data in this way. First, it puts the focus on regional best practice examples. Second, it ensures that data for all modes are presented on the same scale, thereby facilitating comparisons across indicators.

For maritime transport, UNCTAD's *Liner Shipping Connectivity Index* serves as a readily available reference (Figure 10). It uses a statistical methodology, principal components analysis, to combine a variety of liner shipping indicators into a single, broad-based index (UNCTAD 2009). This method produces a weighted average of the underlying data in which the weights are chosen objectively so as to produce an optimal summary measure, i.e. one that accounts for the maximum possible amount of variance in the underlying data. In this way, the LSCI takes account of the following five factors: number of ships; their container-carrying capacity; maximum vessel size; number of services; and number of companies deploying containerships to and from an economy's ports. Factors one, four, and five can be interpreted as quantity measures: they show the number of ships, services, and companies linking an economy with the rest of the world. Factors two and three are closer to being quality indicators, since they provide detail on the type of service provided, rather than just the quantity.

Figure 10 Maritime transport indicator, as a percentage of the regional leader's score

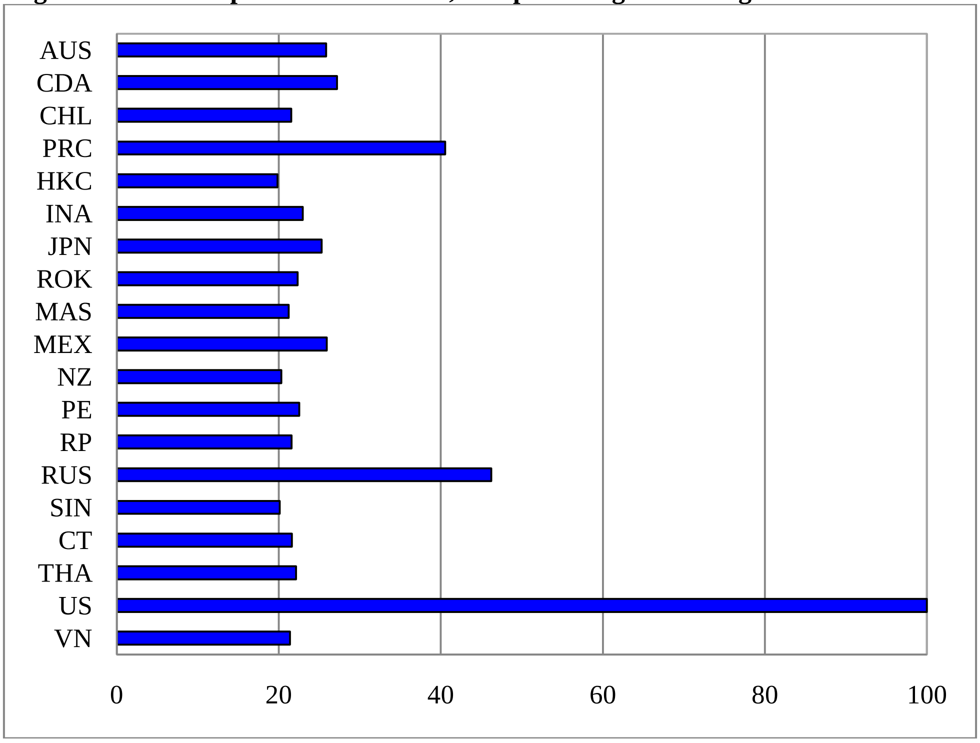


Source: UNCTAD Liner Shipping Connectivity Index 2007.

The LSCI has previously been used in policy analysis. Wilmsmeier and Hoffmann (2008) show that connectivity has an important impact on maritime freight rates. However, the present paper is, to our knowledge, the first one to use the LSCI in an econometric analysis of the determinants of trade flows in goods markets.

No similar indicator to the LSCI exists for air transport.[15] To construct a comparable indicator (see Technical Annex), we use the same statistical technique as UNCTAD in the case of liner shipping. Our air transport indicator (Figure 11) is a weighted average of two underlying data series: the number of primary airports in each member economy; and the number of secondary airports. Both variables are sourced from the *CIA World Factbook*. We use these variables rather than alternative sources such as the *World Development Indicators* or the *Global Competitiveness Report*, since they provide the best coverage of APEC member economies. Moreover, APEC TPT-WG (2007) already makes use of these data from the CIA World Factbook. The total number of airports is a quantity measure of connectivity, whereas the division between primary and secondary airports gives an idea of the quality of the air transport sector.

Figure 11 Air transport indicator 2007, as a percentage of the regional leader's score



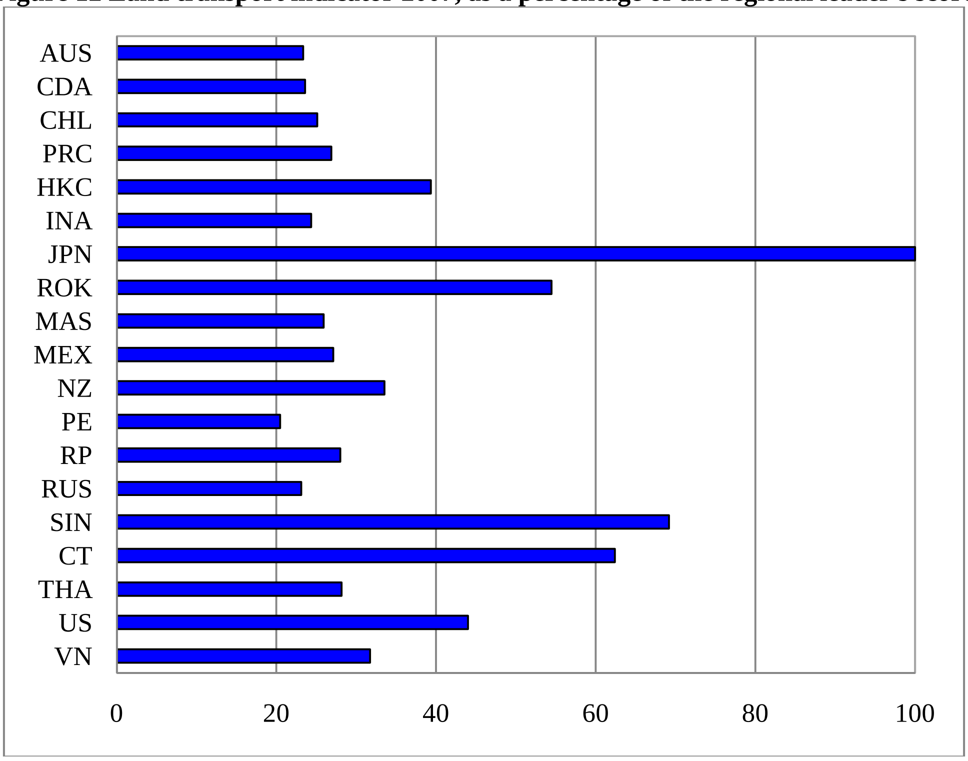
Source: See text.

Land transport is also an important aspect of multimodal transport connectivity. It is primarily associated with the transport of goods within, rather than between, countries. But international trade transactions are often impossible to complete without a strong land transport environment to facilitate shipping between factory, port, and warehouse. We again use the same statistical technique as UNCTAD to produce an overall land transport indicator, based on an objectively-determined weighted average of the following indicators: road infrastructure density; and rail infrastructure density. Each measure is defined as the total

[15] The WTO's *Air Liberalization Index* is in a different category: it measures an input (degree of policy liberalization), as compared with output measures such as the LSCI. We exclude it from the empirical modeling for that reason, and because lack of data availability for many bilateral links makes it difficult to obtain reliable estimates of the impact of liberalization. For detailed results on intra-APEC trade, see Geloso-Grosso and Shepherd (2009). Those authors find that sectors such as parts and components are particularly sensitive to air transport liberalization. A one point increase in a bilateral air services agreement's ALI score is associated with an up to 4% increase in merchandise trade. For an alternative approach to measuring liberalization, see: APEC TPT-WG (2007).

length of the network divided by the economy's total land area; this is a similar approach to Limao and Venables (2001). Dividing by land area in both cases takes account of the special situation of small economies, by focusing on network density rather than just total length. This adjustment is important because some economies that are geographically small have very well developed road and rail links, even though total network length is much smaller than that of some geographically larger economies with less well-developed networks. Both data series are sourced from the *CIA World Factbook*. As for air transport, the composite index captures the twin aspects of the quantity (length of the network) and quality (adjustment for land area) of connections.

Figure 12 Land transport indicator 2007, as a percentage of the regional leader's score



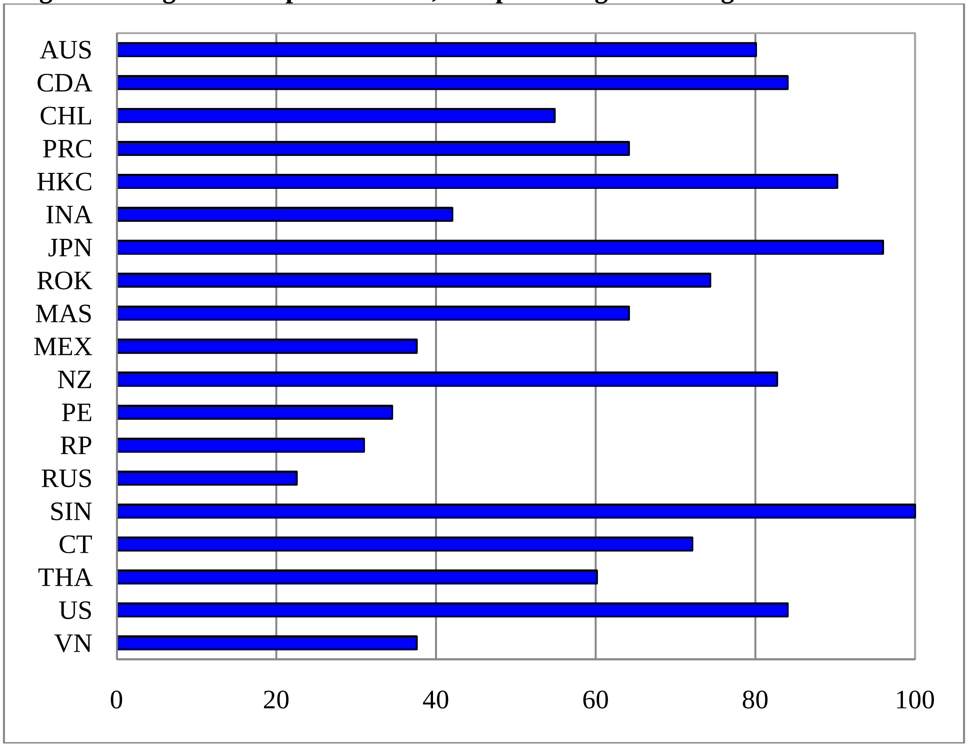
Source: See text.

The final major dimension of multimodal transport connectivity is the logistics environment. Logistics operators are responsible for coordinating complex cross-border transactions involving a variety of transport modes, as well as the necessary interchanges and transshipments. The most comprehensive dataset on an economy's "logistics friendliness" is the World Bank's *Logistics Performance Index*. The LPI is based on private sector perceptions of supply-chain performance and bottlenecks, drawn from survey responses given by logistics professionals around the world. Like the LSCI and our transport indicators, it uses statistical techniques to create a single, comprehensive index based on the following core dimensions: efficiency of the clearance process; quality of trade and transport infrastructure; ease of arranging competitively priced shipments; competence and quality of logistics services; ability to track and trace consignments; and timeliness of delivery.[16] We use one of those dimensions to measure an economy's ability to coordinate complex

[16] The 2007 LPI also collected data on a seventh dimension, namely domestic logistics costs. However, that dimension was excluded from the calculation of the final LPI due to an unexpected negative correlation with the other elements of the index. Thus, the LPI summarizes the six dimensions referred to in the main text, but does not include domestic logistics costs.

multimodal transactions, namely the competence and quality of logistics services (Figure 13). Although the overall LPI has been used in econometric work on the determinants of goods trade (Hoekman and Nicita 2008), the logistics competence component has not yet, to our knowledge, received such detailed attention.

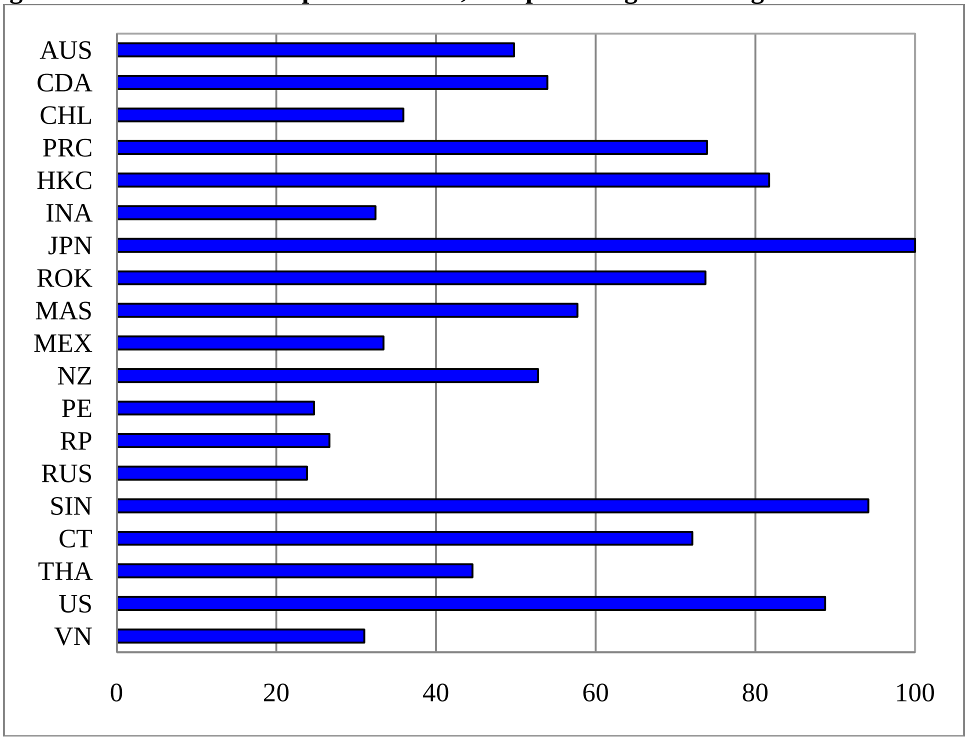
Figure 13 Logistics competence 2007, as a percentage of the regional leader's score



Source: Logistics Performance Index 2007.

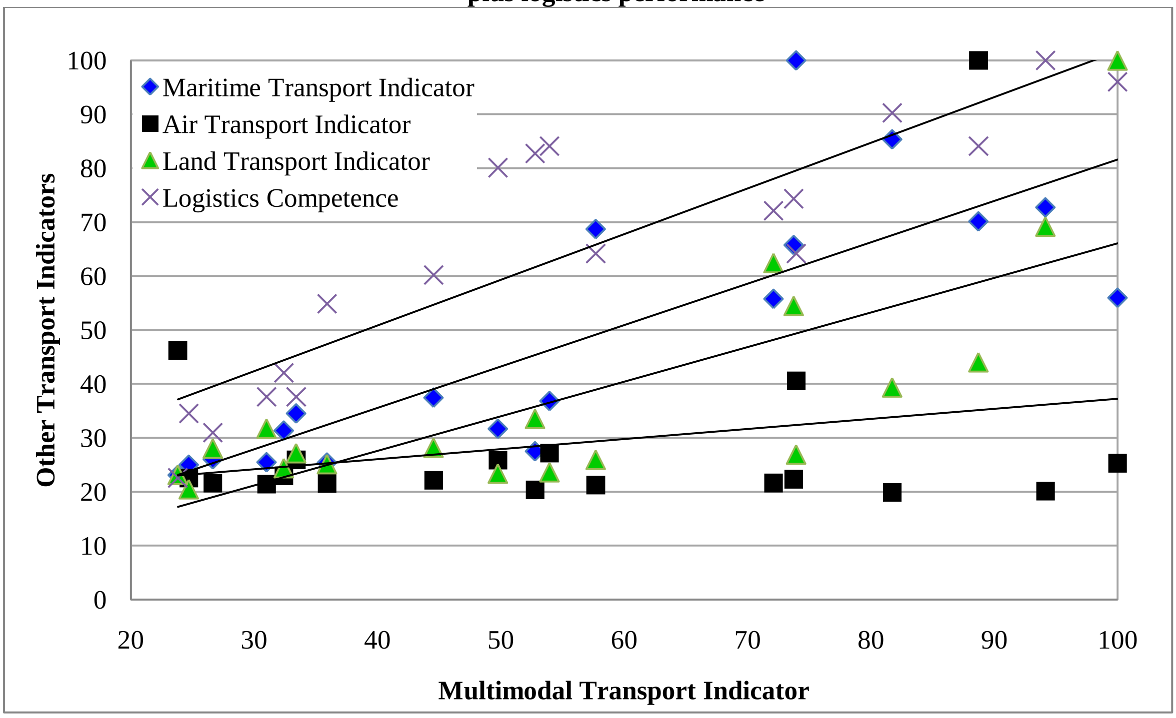
To obtain an overall picture of multimodal transport connectivity across the region, we use principal components analysis to create a summary indicator (Figure 14). This indicator incorporates the air, maritime, and land transport indicators, as well as logistics competence from the LPI. Data is available for 19 APEC member economies. Figure 15 shows that there is a strong correlation between our overall indicator, and each of the modal indicators, as shown by the strong upward slope of each line of best fit. The overall indicator clearly captures an important tendency of the full range of modal data, and should be a useful indicator of multimodal transport connectivity.

Figure 14 Multimodal transport indicator, as a percentage of the regional leader's score



Source: See text.

Figure 15 Correlation between the overall multimodal transport indicator, and indicators for each mode plus logistics performance



Although these measures are based on performance outcomes—such as infrastructure quantity or quality—it is important to highlight the important role that policy can play in boosting connectivity. Facilitating construction and maintenance of infrastructure is one area.

Another is adopting appropriate regulatory environments for service providers. For example, a more liberal air transport environment is strongly associated with better air transport performance using the measure developed above (Figure 16). Recent World Bank work shows that a more liberal regulatory environment for distribution services is associated with higher quality trade logistics (Figure 17Arvis et al. 2010). There is much that policymakers can do in areas such as maritime, air, road, and rail transport to help build private sector capacity and develop a trade-friendly environment.

Figure 16 Air transport indicator vs. Air Liberalization Index (ALI)

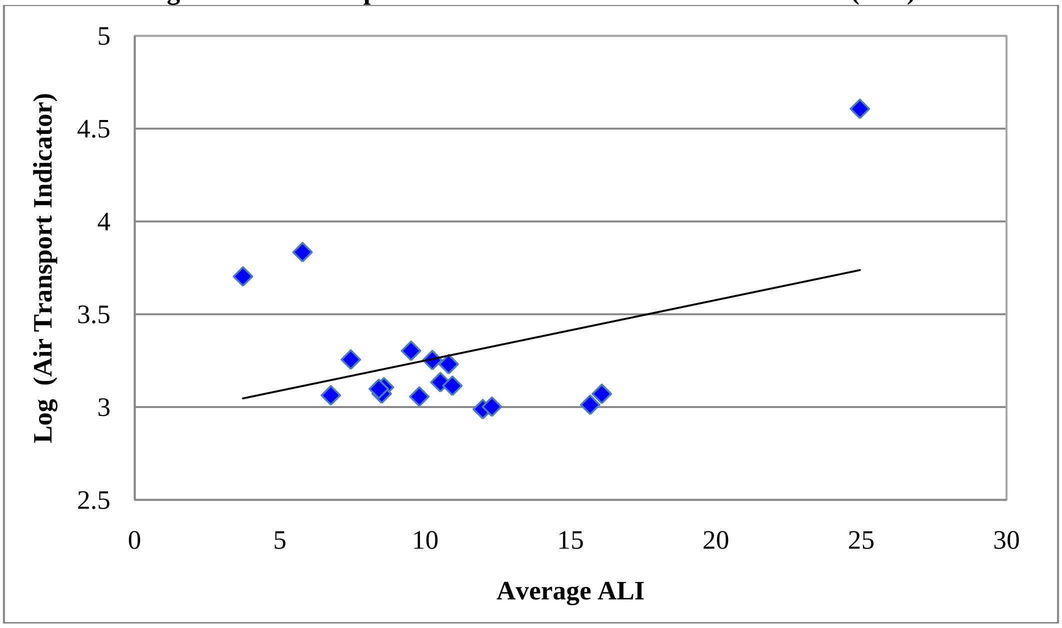
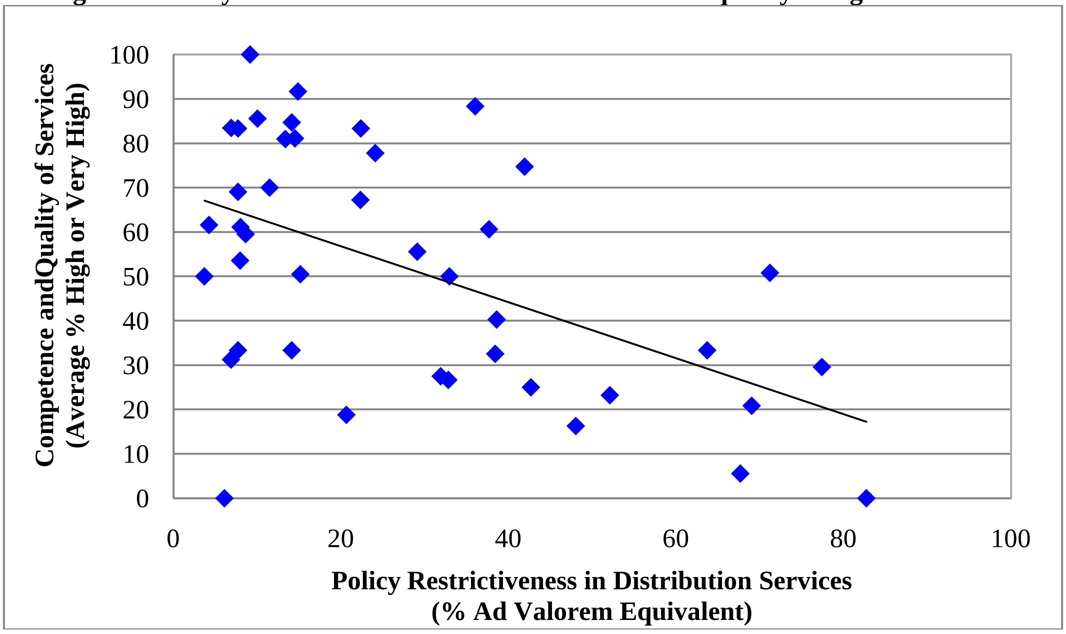


Figure 17 Policy restrictiveness in distribution services vs. quality of logistics services



Source: Arvis et al. (2010).

Box: Principal Components Analysis—A Non-Technical Overview

Principal components analysis (PCA) is a commonly-used statistical technique. It makes it possible to combine a number of underlying indicators into a smaller number of summary measures. Most commonly, it is used to produce a single measure on the basis of a number of input measures. For example, our multimodal transport indicator is a single measure produced from indicators on logistics competence and land, air, and maritime transport. Other examples of PCA's application include the air, and land transport indicators used in this study, as well as UNCTAD's LSCI and the World Bank's LPI.

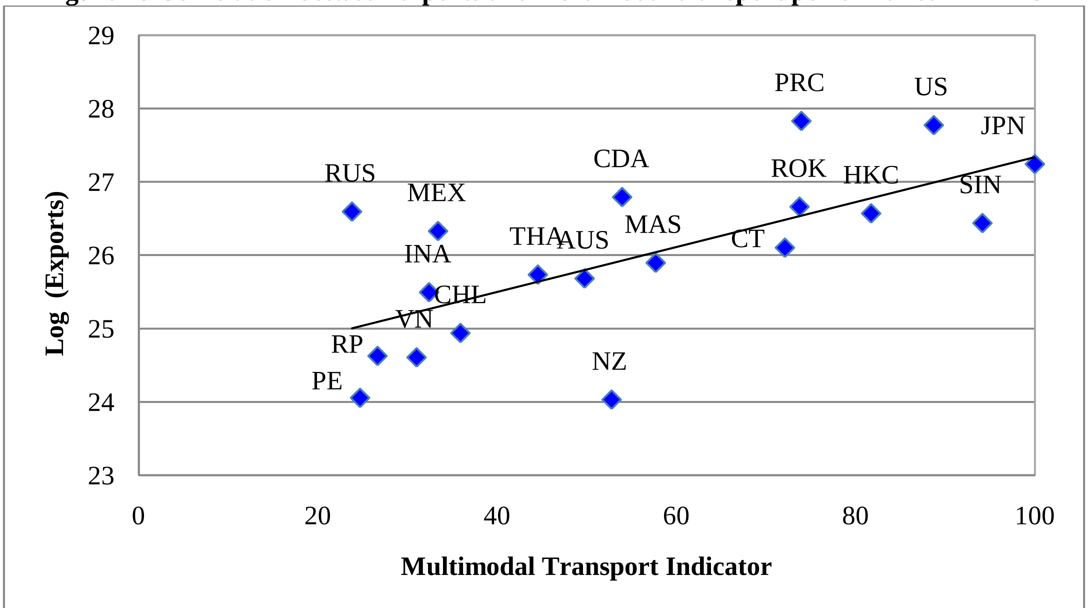
PCA works by analyzing the correlation structure in the original set of indicators. By looking for common variation, it makes it possible to identify underlying connections in the data. The final indicator produced using PCA—for instance our multimodal transport indicator—is a weighted average of the underlying indicators. The weights are determined by applying a mathematical technique which chooses weights so as to maximize the proportion of the variance in the original indicators that is accounted for by the PCA summary indicator. Our multimodal transport indicator is thus the optimal way of summarizing our indicators on logistics competence, and land, sea, and air transport, in the sense that it captures the maximum possible amount of information from the original indicators.

Because of the way in which it works, PCA has the important advantage of producing an objective weighted average of the underlying indicators. Alternative techniques tend to rely on the analyst's judgment, thereby leaving them open to question to the extent that other experts might reach different conclusions. Indicators such as the air, land, and multimodal transport indicators we have developed here are less open to that criticism, because of the objectivity introduced by PCA.

B. MULTIMODAL TRANSPORT AND EXPORTS: AGGREGATE ANALYSIS USING THE GRAVITY MODEL

Figure 18 provides a preliminary analysis of the relationship between multimodal transport performance and trade in APEC. The horizontal axis shows each economy's score on our overall multimodal transport connectivity indicator. The vertical axis shows the same economy's total exports (converted to logarithms to improve readability). The line of best fit is strongly upward sloping: better multimodal transport connectivity is clearly associated with better export performance.

Figure 18 Correlation between exports and multimodal transport performance in APEC



Another striking feature of the graph is that some member economies perform far better than the average relation between multimodal transport and exports would seem to suggest, as indicated by data points well above the line of best fit. In some cases, such as Russia, this result must be interpreted with caution because oil exports play a role in boosting export values, but they are not overly dependent on transport and logistics performance. Given its export mix, the case of China is more noteworthy. It may be that one of the reasons for its strong performance compared with the average is that in such a large and diverse economy, our general measures of transport connectivity do not capture the fact that major international gateways may be of much better than average quality compared with infrastructure in the hinterland.

We use the gravity model of bilateral trade to investigate the association between multimodal transport connectivity and trade in greater depth. It takes account of trade within APEC, and between APEC member economies and the rest of the world (up to 230 economies in total). The model controls for a range of influences on bilateral trade, such as the size of each economy, and the level of trade costs between them. Data are taken from standard sources. The Technical Annex contains an in-depth discussion of the model, data, and regression results.

Box: The Gravity Model of Bilateral Trade

The gravity model is the workhorse of applied international trade analysis. Since its first applications in the early 1960s, it has been used in thousands of published papers, for academic research as well as policy analysis. According to Leamer and Levinsohn (1995), the gravity model has provided “some of the clearest and most robust empirical findings in economics”.

By analogy with Newton’s theory of gravity, the gravity model of trade postulates that the trade flow between two countries—like an economic force of attraction—is larger for bigger countries (higher GDP), and smaller for countries that are further away (higher trade costs). Subsequent work, such as the research the models used in this report, has shown that the gravity model can be given rigorous theoretical underpinnings in microeconomics. It provides a sound and widely-used basis for assessing the extent to which different trade cost factors impact bilateral trade.

There have been a number of well known applications of gravity modeling in the trade facilitation, transport, and logistics fields. Wilson et al. (2004, 2005) use a gravity model to examine the potential for trade facilitation to boost trade in the Asia-Pacific, and globally. Shepherd & Wilson (2009) take a similar approach to studying trade facilitation in ASEAN. Again using a gravity model, Hoekman & Nicita (2008) show that “red tape” trade facilitation and overall logistics performance both matter for the level of trade integration. Geloso-Grosso & Shepherd (2009) find that air transport liberalization is an important determinant of bilateral merchandise trade in APEC, particularly in sectors such as parts and components.

The version of the gravity model used in this paper is close to the widely-accepted “gravity with gravitas” model of Anderson and Van Wincoop (2003, 2004). Due to limitations on the types of data available to measure multimodal transport connectivity, it is not possible to use a specification that is identical to theirs. However, test results using a baseline model without multimodal transport performance suggest that the difference in results is likely to be minor. Our approach represents the best trade-off between analytical rigor and empirical feasibility. Future work can overcome the problems experienced here by developing bilateral (country-pair) measures of connectivity; these data are currently unavailable, however.

Our gravity model results generally sit well with the broader literature. In most cases, commonly-used variables have similar signs, magnitudes, and statistical significance levels to those reported elsewhere.

In addition, the gravity model results provide strong support for an association between multimodal transport connectivity and stronger trade performance. For total trade—i.e., all products added together—all individual transport modes, as well as logistics competence, are associated with stronger bilateral trade links. The association is highly statistically significant in all cases. The closest relationship with trade is for logistics competence: improving an economy's performance by one percentage point relative to the regional leader is associated with an export increase of over 2%. As examples, a one point increase in the logistics competence index would represent an improvement in Vietnam's performance by around 25% of its current gap with Indonesia, or an improvement in Peru's performance of around one-third of its current gap with Mexico.

The numbers are smaller, but still important, for the other modes. The effect of maritime transport is around half as strong as that of logistics competence. A one point increase in the maritime transport index is associated with a trade increase of just over 1%. Next in line comes air transport, with an effect just slightly weaker than that of maritime transport. Land transport has the weakest effect, with a one point increase in the index being associated with a 0.5% increase in trade. This result makes sense in light of the fact that land transport is most important for movement of goods within economies, rather than between them.

We obtain similar results using our overall multimodal transport connectivity indicator. The impact of multimodal transport on trade flows is positive and highly statistically significant. A one percentage point improvement in performance is associated with a nearly 3% increase in exports. This effect is stronger than for any of the component indices on their own. It suggests that the way in which transport modes and the logistics environment interact can give rise to economic benefits in which the whole is greater than the sum of the parts.

One potential issue with these results might be that they are subject to a "virtuous cycle" dynamic: economies that rely heavily on trade have an incentive to improve multimodal transport connectivity so that their trade performance improves further. This kind of reverse causality can potentially result in biased gravity model estimates if nothing is done to correct for it.

We confront this problem using the statistical methodology of instrumental variables, or two-stage generalized least squares (2GSLS). A full description of the methodology is provided in the Technical Annex. The data provide strong support for our approach to dealing with the "virtuous cycle" problem. Econometric results show that although reverse causality indeed introduces some bias into the gravity model results, correcting it does not change our overall conclusion: multimodal transport is positively associated with bilateral trade, and the association is highly statistically significant. In terms of magnitude, however, the 2GSLS results suggest a smaller impact: a one point increase in an economy's multimodal transport connectivity as measured by our index is associated with an export increase of around 1%. Examples of a one point increase of this type would be an improvement in Vietnam's performance so as to bring it to the level of Indonesia, or an improvement in Indonesia's performance to bring it to the level of Mexico. Although substantial, these improvements are clearly feasible over the medium-term, and suggest that the trade gains from realistic reform can be significant.

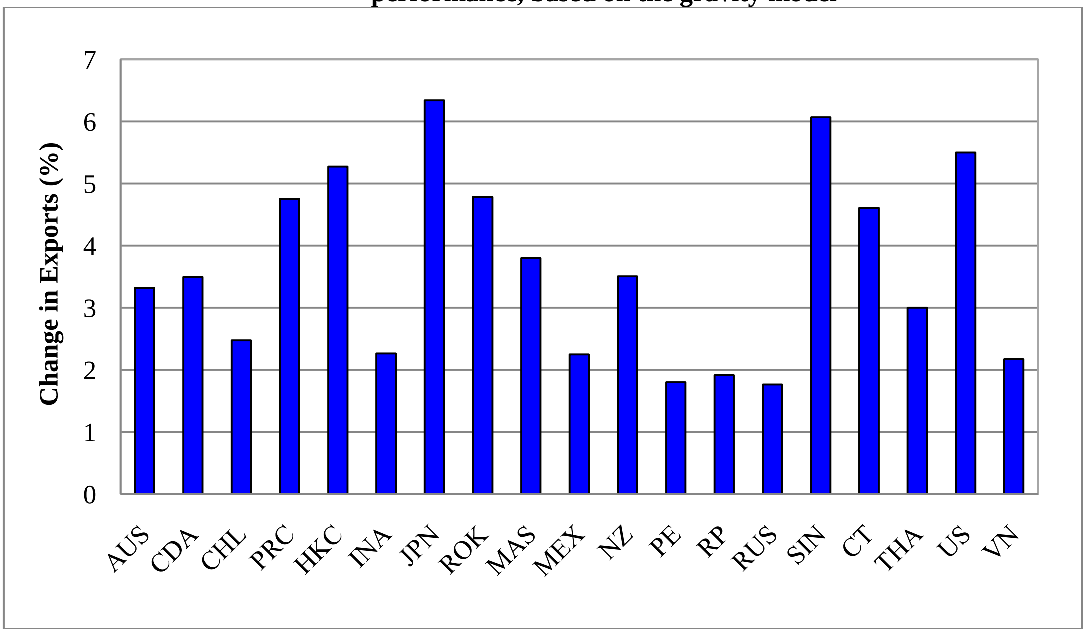
C. THE BENEFITS FROM REFORM: A "WHAT IF" SCENARIO

An alternative way of expressing these results is by simulating the trade effects of reform: a "what if" scenario. We assume that each economy implements reforms that improve multimodal transport performance by 5% from its initial level in 2007. The simulation is conducted so as to model the effects of concerted action on multimodal transport by all APEC member economies together. Other factors, including trade costs in the rest of the world, are kept constant.

Results in Figure 19 show that the trade gains from improving multimodal transport performance can be substantial. The range for individual member economies is between 2% and 6% of baseline exports. In dollar terms, this equates to an impact gain of between $850m and $115bn per member economy. On the whole, exports to the world would increase by nearly $500bn annually or an increase of 4%. High performers in multimodal transport, like Singapore and Japan, have the most to gain: 5% improvements in these economies represent substantial performance upgrades. Economies with challenging multimodal transport environments see smaller, but still significant, gains from reform: at a minimum, an increase in exports of nearly 2% follows concerted reforms that improve multimodal transport performance by 5%.

Another feature of the simulation results is that relatively small and open economies stand to realize significant gains from reform. Although Chile is starting from a transport environment with a certain number of constraints—its score is less than 40% that of the regional leader—it experiences major export gains from reform because its starting level of trade exposure is relatively high; its trade to GDP ratio is just over 40%.

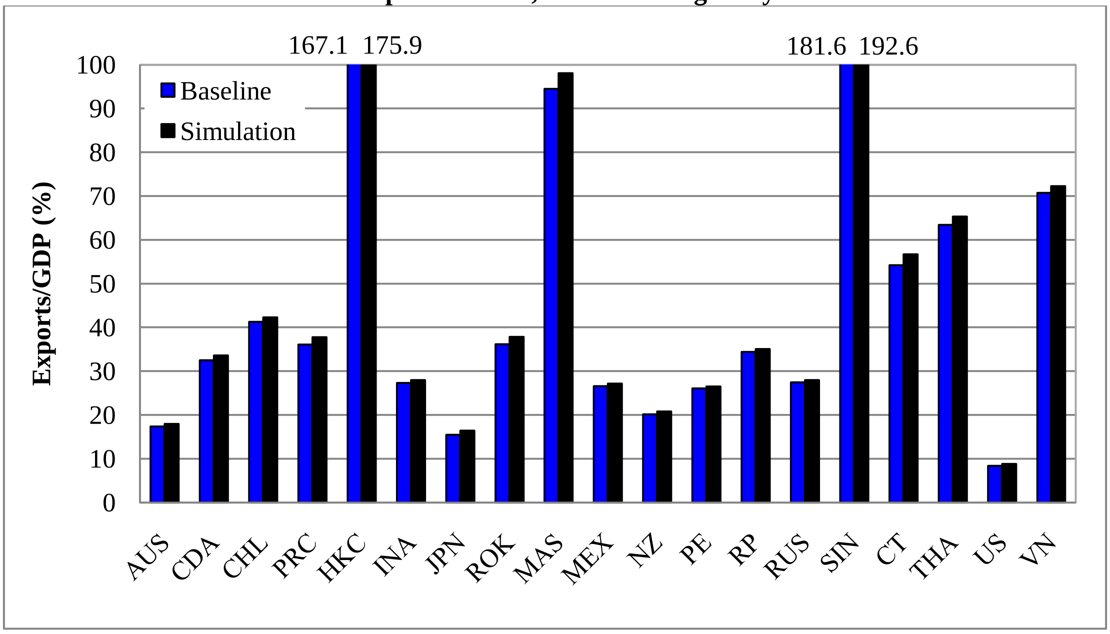
Figure 19 Simulated percentage change in exports from a 5% improvement in multimodal transport performance, based on the gravity model



Source: See Table 9 column 9.

Results from the "what if" analysis can be presented using other performance benchmarks too. Figure 20 uses the exports to GDP ratio. It is again clear that economies starting from a relatively high level of trade integration, as indicated by a high exports to GDP ratio, tend to gain more in absolute terms than do relatively less open economies. The "tigers" of Hong Kong China, Singapore, and Malaysia—and to a lesser extent Viet Nam and Thailand—stand out as experiencing major gains from reform.

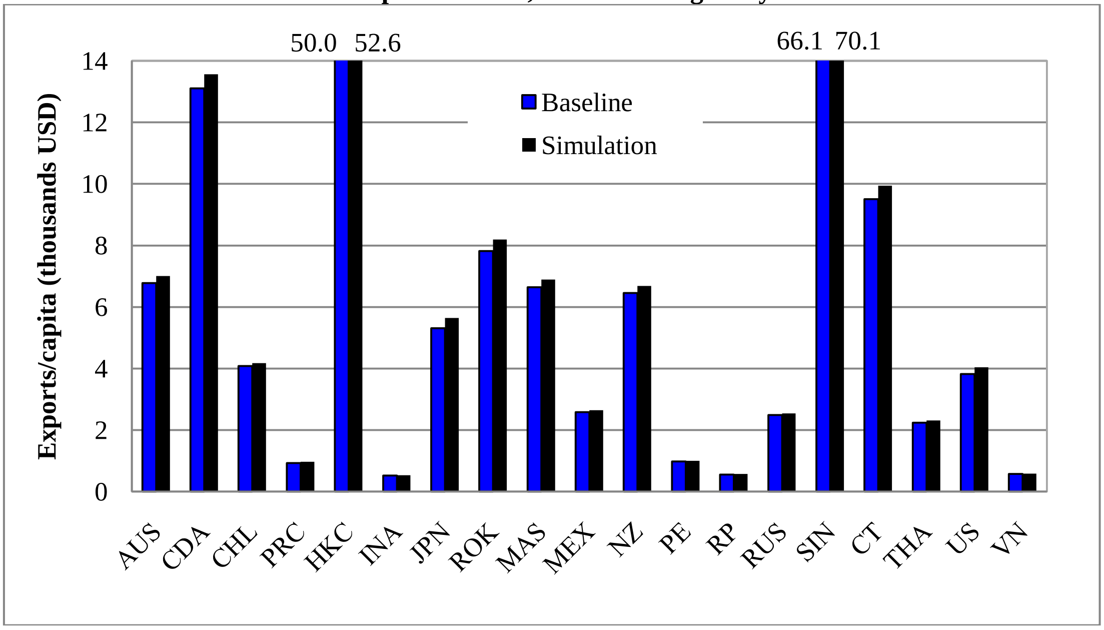
Figure 20 Baseline and simulated export/GDP ratios from a 5% improvement in multimodal transport performance, based on the gravity model



Source: see Table 9 column 9.

Figure 21 expresses results from the "what if" scenario in terms of exports per capita. Again, the largest absolute gains accrue to economies that are already well integrated with the world and regional economies. Economies with strong export sectors such as Chinese Taipei, Japan, Korea, and Malaysia perform well. So too do small open economies like Australia and New Zealand. The two regional trading hubs of Hong Kong China and Singapore experience the largest gains; however, the extent of re-exports and processing trade in those economies means that the results must be interpreted with caution.

Figure 21 Baseline and simulated exports per capita from a 5% improvement in multimodal transport performance, based on the gravity model



Source: see Table 9 column 9.

Like all simulation exercises, this one comes with a number of important caveats.

First, results are expressed as export outcomes, not economic welfare (GDP). In order to assess the impacts of transport reforms on producers and consumers, and to take account of changes in the sectoral composition of production and trade, a full general equilibrium model (CGE) of multimodal transport connectivity would be necessary. Extending the analysis in this way would be an important step in an overall cost-benefit analysis of reform. Given the CGE analyses that have already been carried out in the APEC context, it should be a high priority for researchers to undertake this work on a global or cross-regional basis.

Second, improving multimodal transport connectivity requires investment of substantial economic resources, particularly in infrastructure. The cost-benefit balance of reform is likely to be positive, but the gains reported here would nonetheless be substantially smaller once the costs of improvement are netted out (e.g., Shepherd & Wilson 2007). As a rough figure, an increase in transport-related infrastructure investment on the order of 10% might be required to produce the index improvements assumed in the "what if" scenario (Mirza 2009). Funds for maintaining infrastructure over the medium- to long-term are also important, since depreciation greatly reduces the value of the initial investment, and tends to hamper trade performance.

Third, the gains from reform by APEC member economies would be reduced if similar reforms were to be undertaken simultaneously in the rest of the world. The reason is that multilateral trade barriers would fall at the same time as bilateral barriers. This mechanism tends to dampen the trade-boosting effects of reform. The results of our "what if" exercise should therefore be read as an optimistic view of the benefits reform could bring.

D. MULTIMODAL TRANSPORT AND TRADE: SECTOR-BY-SECTOR ANALYSIS

Some sectors depend more than others on multimodal transport connectivity. To give a first impression of how important these differences are, and the sectors that are most sensitive to improved performance in particular areas, we also estimate gravity models using data for individual sectors. The advantage of this approach is that it enables us to identify potential chokepoints in individual supply chains. Our product disaggregation is very broad, and follows the seven sectors of the Broad Economic Categories classification: food and beverages; industrial supplies; fuels and lubricants; capital goods; transport equipment; consumer goods; and other goods.

The gravity models show that trade in consumer goods is the most sensitive to improvements in overall multimodal transport connectivity. Capital goods, transport equipment, other goods, and industrial supplies follow. There are many possible reasons for this ordering of sectors. One is that many consumer goods in the Asia-Pacific region are manufactured within international production networks. These networks depend heavily on transport links and efficient logistics to move components and finished products across borders reliably and cost-effectively. Improvements in multimodal transport connectivity have the potential to provide a strong boost to trade in this sector.

The gravity model also makes it possible to examine the impacts of different multimodal transport factors across sectors.

Maritime transport plays an important role in exports of consumer goods, capital goods, and industrial supplies. Many of these types of goods have a relatively high weight to value ratio. This feature makes maritime transport relatively more attractive for international transactions. Although it is slower than air transport, it is generally also less expensive, and better suited to bulky and heavy goods.

Air transport is especially important for exports of food, and to a lesser extent consumer and other goods, and industrial supplies. One reason for this result is perishability. High value agricultural exports need to be moved across borders quickly, and often under carefully controlled conditions. These requirements often necessitate air transport. Logistics operations have to be of a high standard to facilitate these kinds of transactions.

Land transport appears to be particularly important for exports of transport equipment. Again, these items tend to have high weight to value ratios, and are generally not time sensitive. These features make land transport a potentially attractive choice.

The most consistent results from any of the four indicators come from logistics competence. It is a significant determinant of trade performance in all sectors. This finding highlights the importance of making all transport modes work together through an efficient logistics sector. Logistics is most important for other goods, followed by food and beverages, capital goods, consumer goods, transport equipment, and industrial supplies.

4. CONCLUSION AND POLICY IMPLICATIONS

A. CONCLUSION

The gravity model has been a useful platform in exploring the links between multimodal transport connectivity and APEC exports. Taking the results from the modeling exercise together, we find strong evidence that multimodal transport matters for trade. Of course, different types of transport matter more for some sectors than others. Overall performance, however, is vital in most sectors—and this is particularly true for logistics competence, including the private sector's ability to manage complex international transactions that involve multimodal linkages.

The gains from reform in multimodal transport are potentially significant. The APEC region would increase exports by around 4%, or between 2% and 6% per member economy. In dollar terms, this equates to an impact gain of $500bn or between $850m and $115bn per member economy. Economies that are open, highly integrated into world markets, and with strong multimodal connectivity stand to gain even more.

Future policy research could extend our results in a number of ways. First, as new data become available, it will be possible to improve the gravity model specification by using panel data techniques. This approach will make it possible to ensure that a wider range of external influences are excluded from the model, and thus support the robustness of our results.

Second, connectivity in individual transport modes could be assessed using network analysis methods. The advantage of using network analysis is that such techniques capture the importance of an economy's position in the international transport system, not just the quantity and quality of its infrastructure and logistics performance. Adjusting for network effects is particularly important for small economies that act as important regional or global hubs, and would tend to boost their connectivity score. However, the data for undertaking this type of analysis are not yet widely available, and appropriate methodologies are still being developed. Data requirements include detailed geographical and frequency information on individual sea, air, and land routes. For sea and air connectivity, data can be extracted from industry sources. For land connectivity, use of geographical information systems modeling (GIS) is required. At the present time, this work has only been done for a small number of specific regions regarding land transport (e.g., Shepherd and Wilson, 2007, for Eastern Europe and Central Asia).

Third, it will be important to undertake detailed cost-benefit analysis of individual reform projects. Improving multimodal transport performance often requires substantial investments in infrastructure, with real economic costs. The balance is generally positive, but each project needs to be evaluated on its own merits.

B. POLICY IMPLICATIONS

Our gravity model analysis shows that improved multimodal transport connectivity can provide a significant boost to export performance in APEC. At least four sets of policy implications flow from this finding.

First, infrastructure remains a key constraint in some member economies. Investing in trade- and transport-related infrastructure such as ports, airports, road, and rail links should remain a priority. Mobilizing finance for such investments can be challenging in the context of the Global Financial Crisis, and there may be scope for economies to work together on a regional or sub-regional basis to help overcome these constraints. Facilitating trade through regional transit corridors can also be beneficial. Private-public partnerships can be a key component in building and upgrading infrastructure, as well as ensuring an appropriate level of maintenance over time (see below). This is a topic being discussed under the purview of APEC's Senior Finance Officials Meeting (SFOM).

Second, it is important to set funds aside for infrastructure maintenance in addition to construction. Depreciation of roads and other infrastructure tends to diminish their usefulness—and their trade effects—over time. Continuous upgrading is necessary. The return from investment in infrastructure maintenance can be very high, but setting up sustainable maintenance systems is a challenge for many economies.

Third, a supportive regulatory environment can help improve multimodal transport connectivity. As shown in the main text, a more liberal air transport environment is one way of boosting overall air transport performance. Recent work by the World Bank similarly suggests that a more liberal regulatory environment in distribution services helps promote higher quality logistics services. Regulatory reform based on rigorous cost-benefit analysis can clearly have major economic benefits in this area. The private sector should of course be involved as far as possible in the regulatory reform process. The real economic costs of designing and implementing regulatory reform are very small compared with infrastructure investments, although the political economy constraints can be significant. Nonetheless, they may represent "low hanging fruit", in the sense of large gains that can be acquired relatively inexpensively. This is not to understate the technical complexity of reform, however. A whole supply chain approach means paying attention to the full range of regulatory, contractual, and competition policy issues that arise.[17] Coordination among the various actors is vital.

Finally, private sector development is also a key element of improving multimodal transport connectivity. Indeed, it may even be the most important part of the overall reform agenda. Our research shows that the quality and competence of private logistics services can have a stronger effect on trade performance than the other areas of multimodal transport examined here. Building human and financial capacity in the logistics sector should remain a priority for member economies. So too should involving the private sector in infrastructure upgrading, maintenance, and regulatory reform. Civil society is an important partner in these processes, and appropriate involvement can help ensure adequate information flows to governments, as well as create an environment of positive compliance and partnership.

[17] The experience of the Australian Competition and Consumer Commission is instructive in this regard: Samuels (2010).

These observations are particularly important for developing member economies. Achieving the right balance between infrastructure investment, maintenance, and private logistics sector development remains crucial to enhancing overall competitiveness and boosting trade performance. Moving forward on all fronts simultaneously is likely to bring the greatest rewards.

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ANNEXES

A. ECONOMY-SPECIFIC ISSUES AND CHALLENGES

As per the terms of reference, the purpose of this annex is to identify "the chokepoints that impede multimodal connectivity in the Asia Pacific region today". The materials included in this review of the literature should ideally fit the following criteria:

1. Date of publication should be within the last 3 years (between 2007 to 2010);
2. Source should be credible, such as a business association or industry group, international organizations (i.e. OECD, WB and ADB), government agencies (in-house or commissioned), or research institution;
3. Publicly available; and
4. In English (although we were able to translate a few materials written in Chinese and Spanish).

Additional relevant inputs from individual economy were also received. Due to the limited availability of materials that fit the above criteria, it was not possible to conduct a uniform review of the literature on the chokepoints across all economies.

Australia

The Australia National Transport Commission (2008) identified a number of priority areas, issues and challenges that the transport sector faces:

- Economic Framework for Efficient Transportation Marketplace – inefficient market signals (e.g., through pricing and access regulations) leading to poor modal choices and decision making.
- Infrastructure Planning and Investment – insufficient investment over a sustained period, absence of strategic foresight in terms of planning for infrastructure, lack of alignment of policy and infrastructure investment, poor coordination of Commonwealth, State or local government infrastructure investment proposals, and lack of long term land use planning and banking for future transport needs across all modes.
- Capacity Constraints and Supply Chain Performance – A major challenge is the failure to co-ordinate investment across the supply chain and anticipate forecast demand. The Report notes that freight operations have shifted from a modal approach to 'whole of supply chain.' Major impediments to improved supply chain collaboration can be traced to poor logistics chain visibility, competitive tensions that create a culture where companies do not share information, differing regulatory models applying to parts of the supply chain, and the presence of multiple supply chain participants. It also notes that industry has called for a supply chain approach to policy and infrastructure development but that there is limited knowledge of how various supply chains work.

Other priority areas include urban congestion, environment and energy, safety and security, strategic research and technology and workforce planning and skills.

Brunei Darussalam

ALMEC (2008) provides a brief assessment of the present condition of transport infrastructure in Brunei Darussalam. For maritime connectivity, Muara port is considered the one with the international logistics importance, with 2 container berths and 6 berths as a whole. The total cargo handling volume is 1.768 MT or 108,000 TEU as of 2005, most of which are import cargo. Liner shipping services are available with several ASEAN ports such as Singapore, Port Klang, Laem Chabang, Bangkok, Penang, Sandakan, Kuching, Pasir Gudang, and non-ASEAN ports such as Shanghai, and Hong Kong. The port is operated by a Singaporean port operator with advanced and sufficient cargo handling facilities. In terms of land connectivity, there is no railway service in Brunei Darussalam but the road condition is assessed to be favorable. Finally, in terms of airport, Brunei International Airport is identified as the one with the international logistics importance. The airport has advanced and sufficient cargo handling facilities.

Canada

The Canadian Chamber of Commerce (2008) has called for the development of an objective-based National Transportation Strategy that embodies four guiding pillars: a North American vision, a multimodal transportation infrastructure investment strategy, a competitive regulatory and fiscal environment, and a strategy that is economically, socially, and environmentally sustainable. They argue that Canada requires a new vision for an efficient and cost-effective transportation system in view of the following factors: increasing global competition, integrated global supply chains, the growing services sector and urbanization in Canada, current and forecasted skills shortages, recent fluctuations of the Canadian dollar and fuel prices, and growing environmental concerns. It notes that while a number of positive transportation initiatives and policies have been implemented over the years, these have not been guided by a long-term and predictable strategy. Significant investment and modernization of the transportation regulatory environment are required as the current environment consists of inefficient tax and operating requirements and split responsibilities between levels of government.

The Chamber further suggests that the Strategy pursue, among other things, these objectives: (1) The development of the safest and most effective multimodal transportation system by integrating policies concerned with the movement of goods and people in marine, air, rail and road transportation, warehousing facilities, urban transportation, border security, and transportation information flows and (2) To make Canada a competitive gateway for inbound and outbound trade and travel between North America and the rest of the world, attracting 10 to 15 percent of the forecasted trade into North America.

Chile

In Chile, approximately 90% of international trade cargo is transferred through maritime transportation. In general, Chile enjoys an active ports system, with low accident levels and efficient use of its resources. Private investment in the Chilean port system between 1990 and 2009 to date has been close to US $1.394 billion dollars. However, challenges in logistics for companies are high as the port receives US$150 for each container received, but it can cost up to US $980 to process and transport the container to Santiago. In certain ports, obstacles include the lack of docking spaces for the cargo ships and stocking space for the cargo being unloaded. It seems that warehousing problems are the most pressing challenge for Chile's logistics performance. Over the last few years, approximately 750,000 square meters of warehouse and storage facilities are now concentrated in four areas of greater Santiago: Quilicura, Lampa, Renca and Colina. (Cintron (2009).

For air transport, Chile performs well within the Latin American region. The air links are provided via the 7 international airports that carried nearly 5 million passengers and 280,000 tonnes of cargo to and from Chile in 2008. Santiago's Arturo Merino Benítez Airport has received numerous international awards including being ranked as the best airport in Latin America by Latin Trade in the magazine's "The Best of Latin America 2008" report. In addition, Santiago's airport was ranked as the airport with the best service and value in Latin America by ALTA (Latin American Association of Air Transport) in 2007.[18]

China

Transdata (2010)[19] identifies the main pressures in the current transport system in China. One is sustaining funding for projects under construction. A large number of new projects on transport infrastructure entered into construction last year, and this year would expect a peak of investment requirements from those projects, thus there is certain pressure to ensure supply of capital. Another is on transport industry safety and stability. The large amount and size of infrastructure projects this year, coupled with their complex geological environment, require but find difficult to maintain high quality and safety regulation. Especially in recent years, the extreme weather and natural disaster some regions face have greater impact on the normal operations of highway, waterway, and air transport infrastructure. Energy conservation is also an issue. For example, the recent tightening by the European Union on fuel standards of shipping, would affect much on China's shipping companies entering EU ports, and operations costs.

KPMG (2008a, 2008b, 2009) examines the investment environment for foreigners in Chinese infrastructure, transportation and logistics sectors. It also provides some good points on these sectors in China to further open up and develop. For example, the domestic shipping industry, comprising coastal and inland waterways, remains protected from foreign investment. Cargo is growing even faster than passenger traffic, yet there are still few well established freight hubs throughout China. Another challenge facing companies as they grow and expand across China is coping with the fragmented logistics and distribution networks. It also recognizes that as a percentage of GDP, logistics costs are over 18 percent, and have been around this level since 2001. This is high compared to developed economies, where logistics costs are typically below 10 percent of GDP. As a result, one of the key issues facing the industry is operational inefficiency.

ADB (2008a) highlighted the following major challenges of the logistics industry in China:

- There is a lack of coordination among different government departments and organizations. As government agencies are structured along modal lines, they manage intermodal issues mainly from their own perspectives. This results in an array of fragmented legal and regulatory structures, inconsistent technology standards, and lack of interoperability between different transport modes.

[18] http://www.investchile.com/the_chilean_advantage/infrastructure/transport
[19] http://www.transdata.com.cn. "Transport Performance Analysis in 2010 Q1" (In Chinese)

- Due to imbalanced infrastructure, transport bottlenecks and gaps in the interconnectivity between modes still exist, particular in central and western PRC and rural regions.
- Trucking and barge companies are fragmented and consist of many small owner operators[20], lacking efficiency in terms of economies of scale. No single company commands more than 2% of the market or provides nationwide intermodal transport services. Lack of standardized container-carrying wagons or container trucks has led to additional costs in loading and reloading, especially when multimodal transport is used, resulting in low truck productivity levels.[21] In addition, logistics services' poor credibility and integrity acts as another barrier to efficient logistics.
- Inadequate human resources, many of whom lack logistics management knowledge and skills, hamper the industry's further growth.

Hong Kong, China

Being a comparatively small market with only a little manufacturing activity, a considerable proportion of goods handled by HKC is transhipment and of the total freight throughput handled by HKC, almost 70% were originated from or destined for South China, mainly the Pearl River Delta. HKC's multimodal connectivity to China and other parts of the world therefore plays a pivotal role in its being a major trading and logistics hub. In this regard, HKC's air, sea and road transportation modes are individually well-developed and smoothly interconnected with one another. Nevertheless, in the face of the growing competition along the global supply chain, the HKC Government needs to work on the provision of infrastructure to further improve HKC's connectivity. It is noted that the Airport Authority Hong Kong is conducting the Airport Masterplan 2030 Study to map out the infrastructural needs of the airport in the next 20 years including the need and feasibility of building a new runway in addition to the existing two. Moreover, the HKC Government is also exploring the feasibility of developing a new container terminal in Southwest Tsing Yi (i.e. Container Terminal 10) having regard to the projected growth in cargo throughput.

On the land front, it is pursuing the construction of the Hong Kong-Zhuhai-Macao Bridge, an idea first emerged many years ago which have strategic significance in HKC's connectivity with China. The construction of the main bridge finally commenced in December 2009. It should however be highlighted that the implementation of major infrastructural projects is not always easy. Apart from the substantial capital investment required, there is often a competing use of land resources and the HKC community is generally very concerned with projects which may have an impact on the environment. Thus getting a project from the drawing board to the eventual commencement in operation takes time and involves a lot of challenges.

Indonesia

ALMEC (2008) provides a brief assessment of the present condition of transport infrastructure in Indonesia. The major ports include Tanjung Priok, Surabaya, Semarang, Belawan, and Makassar, handling most of Indonesia's export and import cargoes (container cargo). Most of the domestic traffic originates or is destined to these five ports. The largest

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[20]Most barge and trucking firms have one to three vehicles and self-powered small vessels.
[21]The average annual output per truck in Canada is 12 times more than the output in the PRC

port, Tanjung Priok port, has a total of 78 berths and 14 container berths. Total cargo throughput is 36 MT of which half is domestic one, and container cargo throughput is 3.6 million TEU. Inter-island shipping is the prevailing means for distributing goods in Indonesia. The cargo volume by inter-island shipping far exceeds international cargo volume. Roads play a significant role in cargo transportation (96% of total cargo). Although the road has been developed especially for access to major economic centers, traffic congestion in the cities has been chronic issue. Indonesia has four unconnected railway systems, one in Java and three in Sumatra, most of which are singled track and not electrified. In terms of air connectivity, major international airports include Soekarno Hatta, Surabaya, Medan, Semarang, Denpasar, Manado and Palembang. Air freight transport is rapidly increasing, partly driven by the insufficient sea and land transport networks and relatively lower fare.

World Bank (2008) noted that Indonesia's logistics performance is average compared to other economies in the region, but it ranks low on competence of the local logistics industry (both private and public logistics service providers such as road transport operators and customs brokers) and timeliness of shipments in reaching destination. A three-pronged approach is suggested to reduce these bottlenecks in the short term which include: (i) reducing port congestion; (ii) improving hinterland connections; and (iii) improving the efficiency of trucking and freight forwarding services.

In addition, World Bank (2010b) suggests the following options for addressing logistics bottlenecks in Indonesia:

- Congestion is a major issue at Tanjung Priok Port and its terminals, such as Jakarta International Container Terminal (JICT). In the long run, a new deep water port should be considered.
- Improve connections between gateways and internal markets. One part of this involves facilitating inter-island shipping.
- Develop national road infrastructure, such as the Trans-Java Highway.
- Improve the quality of trucking and freight-forwarding services.

Japan

The Ministry of Land, Infrastructure, Transport and Tourism (2008) recognizes the need to support construction of infrastructures which includes:

- Improvement, effective use and enhancement of road networks: MLIT pushes forward the effective use and enhancement of existing expressway networks, through the improvement of ring road systems and the reduction in expressway tolls
- Improving and developing Shinkansen lines: The ministry pushes forward the improvement of Shinkansen lines, which are high-speed, safe and environment-friendly mass transport facilities serving as the framework of Japan's national territory.
- Enhancing convenience in international travel: The ministry will expand the maximum use of international aviation in metropolitan area to 24-hour operation, focusing on the utilization and connectivity between Haneda and Narita airport.
- Improving access to airports: The ministry pushes forward the development and installation of the Narita New High-Speed Railway, which will have world-class capacity to swiftly deliver passengers to the airport, so that the railway will go into service in FY2010.

- Constructing ports and harbors to serve as nerve centers superior to other major port facilities in Asia in terms of costs and services: The ministry pushes forward the improvement of next-generation, high-standard container terminals and the development of coastal physical distribution bases, and also promotes the comprehensive intensive reform program of container-based physical distribution centered on Super-hub Ports, so as to formulate seamless physical distribution networks connecting both domestic and overseas destinations.
- Streamlining physical distribution, and invigorating areas surrounding airports, ports and harbors: The ministry supports efforts among physical distribution transport operators, cargo owners and municipalities aimed at streamlining physical distribution in a local community or an urban area where physical distribution facilities converge, such as airports, ports and harbors.

Republic of Korea

Lee and Kim (2009) state that Korea has increased investment through the development of logistics parks, free-trade zones, port alliances, and marketing initiatives to reach the goal of transforming the Busan and Gwangyang (the two-hub port strategy) into a global logistics hub. However, the authors identify a number of obstacles facing the "two-hub port strategy" in terms of international specialization, global shift of local manufacturing companies to other economies resulting in decreasing FDI, rapid economies changes in Northeast Asia, challenges from nearby Chinese ports, inefficient policies regarding domestic logistics, and traffic concentration at Korea's core economic region. They also suggest the government arrange efficient transport connections between the two ports with regard to road, rail and barge shuttles, and further reform the ports' governance structure.

Malaysia

ALMEC (2008) provides a brief assessment of the present condition of transport infrastructure in Malaysia. The major ports for international logistics in the Peninsular include Port Klang (central region), Penang Port (northern region) and Pasir Gudang / Port of Tanjung Pelepas (southern region). Each port has advanced and sufficient facilities including EDI system and ample handling capacity against the present demand. Port Klang, the largest port in Malaysia has 21 container berths (49 berths as a whole). It handles 109.7 MT of cargo throughput and 5.5 million TEUs as of 2005 accounting for 77% of total port cargo in Malaysia. Transhipment activities have increased in Malaysia recently, with a total of 7.1 million TEUs transshipped as of 2005. The Port of Tanjung Pelapas (PTP), which was strategically designed for transshipment hub, had the largest share of 54% or handled 3.85 million TEUs in 2005. In terms of land connectivity, the highway condition in the West-Peninsular is quite favorable. The North-South Express Way and its connected sections are well developed with no noticeable bottlenecks. However, remaining sections are not in good condition. Thailand border area is also well developed at the Malaysian side, where cross border transport services are widely available. For air connectivity, the major airports for the international logistics in the Peninsular include Kuala Lumpur International Airport (KLIA) and Penang International Airport (PIA). Both airports have advanced and sufficient facilities including EDI system and ample handling capacity against the present demand. KLIA is equipped with 24-hour Free Commercial Zone facility, which can handle 1 million tonnages of air cargo for both inbound and outbound as well as transshipment cargo. Its cargo handling operations have been improved, where the transit time for export/import is at par with global standards.

Although Malaysia has been successful in developing and modernizing its infrastructure, Naidu (2007) cites shortcomings or areas which could further be improved. Issues include: (1) Subjecting infrastructure projects to rigorous evaluation and selecting projects within the context of long-term sector plans, (2) A clearer demarcation of the roles of the public and private sectors in infrastructure, (3) Improving the efficiency of infrastructure service providers or operators who possess significant monopoly power by imposing performance standards, (4) Ensuring that the terms and conditions of private participation in infrastructure lead to efficient and cost effective outcomes, (5) Bridging the infrastructure gap in less developed regions, (6) Ensuring that competition between rail and road transport is on a level playing field, and (7) Formulating a rational policy on the issue of prices for the use of infrastructure services to ensure that maintenance, expansion, and modernization of facilities are not compromised.

Mexico

According to an OECD report (2007), Mexico's road network is deteriorating with age, and maintenance is insufficient. Road density is low and has not changed much over the past 20 years, despite the rapid growth in cargo and passenger traffic over that period. Despite recent improvements, in 2005 only 24% of the federal non-toll roads were in good condition – 54% of them were in normal condition and 22% in poor condition. In terms of security, federal roads are becoming safer – the number of assaults on cargo trucks was reduced from 952 in 2000 to 209 in 2004. There is very little information on the quality of roads at the sub-national level, the guess would be that the situation seems to be even worse for state and local roads than for the federal network. OECD suggests increasing public spending on road maintenance as well as to improving and expanding the connectivity of the road network. The poor and inefficient infrastructure at the US-Mexico border is also highlighted as an issue.

OECD considers the key competition issue in railways is in resolving disputes between the railway companies over inter-regional traffic in order to boost efficiency of the railway system as a whole. This issue has caused interlinear traffic running across the whole network has fallen as a share of total traffic. In terms of ports, while reforms have improved the efficiency of port operations, particularly the unloading of cargo from ships to the wharf, there is still issue related with handling, customs processing and transfer to land transport. For air cargo services the main issue is the lack of investment. Air cargo services are not as profitable for airports (compared with passengers) and, therefore, there is less incentive for them to invest. Air cargo growth may be constrained by this lack of investment; air cargo volume has not grown as fast relative to GDP as it did it the late 1990s. The Government could encourage other parties (such as the airlines) to invest in air cargo services and should review whether the current concessions arrangement is constraining investment.

New Zealand

New Zealand has just released its first National Infrastructure Plan (NIU 2010) which reflects a three-pronged approach to infrastructure development:

- a step change in the level of Government investment, with expenditure targeted at key infrastructure policies
- improving decision-making and management of the Government's infrastructure assets; and
- improving the regulatory environment to facilitate the private sector's investment in infrastructure.

The Plan covers economic or network infrastructure as well as the main social sectors where asset management is important. Some of the key issues and challenges affecting transport infrastructure include improving pricing mechanisms and coordination/integration for road transport as well as meeting the projected increased demand for the transport of bulk commodities (an increase of 70% by weight to 2031) for rail. It is likely that rail will continue to be competitive in general freight and container transport in certain parts where economies of density are exhibited, such as between Auckland and Tauranga. Although it is recognized that rail will continue to be an important part of New Zealand's transport infrastructure, the growth is only likely to be in specific parts of the network, and many other parts of the network will remain under-utilized and uneconomic. An important decision has to be made about what size rail network is to be supported with taxpayer funds. The port sector is deemed to be functioning reasonably well as there is no apparent congestion. There is a diversity of ports providing shipping companies/importers/exporters with range and choice. Moreover, the competition between ports forces them to operate efficiently, to forecast future trends as best they can, and to rationalize and invest where appropriate. With respect to air transport, compared with overseas airports, New Zealand's are relatively free of congestion.

Papua New Guinea

According to an ADB report (2008b) the provision of infrastructure in PNG is a serious binding constraint contributing to the high cost of doing business and reducing the capacity of industries to compete internationally. Along with poor infrastructure, it cited weak property rights, lack of competition, and the dominant role of the state in the economy— which limits competition—as resulting in high transactions costs. The report recognizes that PNG faces obstacles in supplying good quality infrastructure in many areas due to its challenging physical terrain. For road infrastructure, its poor condition is cited as a serious impediment to doing business. It contributes to higher operating costs per truck and also to disruption in marketing systems as the time required to transport products from farm to market increases. The lack of road development, including feeder roads, is a serious chokepoint affecting the development of rural agriculture and business. In terms of ports and shipping, PNG has 17 main public seaports, 11 of which are designated as official ports of entry. Lae, Port Moresby, and Rabaul are the main ports, and the only ones that are profitable. The report states that unlike other infrastructure, ports do not appear to be in great need of widespread upgrading.

The ports serving Port Moresby, Lae, Madang, Kimbe, and Rabaul carry international and coastal traffic and have a reasonable level of infrastructure, but lesser ports, ranging from those at Wewak, Kavieng, Oro Bay and Alotau to mere timber jetties and beach landings, provide only a basic service for coastal traffic and are often unusable in bad weather. Lae is the main import/export point for the populous Highlands region, the goods moved from/to the port by road. Annual throughput by the major ports has been growing at about the rate of population growth with import/export tonnages (increasingly containerized, but also including a growing logging trade) accounting for about a third of the total and most of the growth.[22]

Peru

World Bank (2009b) noted that Peru's relative competitiveness is being hampered by the poor quality of its transport infrastructure. Because of the poor quality, firms need to have high inventories, to account for contingencies which lead to higher unit costs, lowering competitiveness and productivity. The report further stresses that Peru's Road safety conditions are among the worst in the region.

In Peru, there are only 11,783 km of paved roads, of which 10,643 km are national roads. Only 34 percent of the national roads are in good condition, 51 percent are in fair condition and 15 percent in poor or very poor conditions. For the unpaved network, the situation is even worse with only 3 percent being in good condition and 34 percent in fair condition. Although Peru has a deficit in road infrastructure, in recent years, the number of road concessions has been increased considerably. According to the Peruvian Economic Institute (IPE)[23] until 2004, only two concessions had been given (Arequipa-Matarani and Ancon-Huacho-Pativilca), while by 2008 nine road concessions were under implementation and in 2009 three more concessions were granted; covering an extension of 4 628Km and with a total estimated investment of US$ 3 148 million, of which US$ 1 016 million has already been executed.

In addition, it is worth noting that in mid 2006, the concession contract for the construction and administration of the South Pier of the Callao Port was signed with the consortium formed by companies DP World and Uniport SA. This concession is valued at approximately US$ 617 million. This process is important since most of Peru's international trade passes through the port of Callao. As an initial commitment, US $ 360 million will be invested in the construction of two berths, where six gantry cranes will be installed. This investment, which would be culminated in 2010, will be fundamental to streamline inefficient and lengthy process that currently has the port of Callao. Furthermore, in August the grant of the North Pier would be defined and six other processes for ports concessions are being carried out.

Peruvian Ositran[24] website (www.ositran.gob.pe), lists other bottlenecks. For example, Peru suffers somewhat inadequate port infrastructure. Reduced operating depth in docks, dock maneuvers and input channels, does not allow entry of modern vessels with larger draft that supposedly would reduce operating costs of vessels. There is also an issue of lack of space for the development of port areas, highlighting the problem of shortage of docks, storage areas and operative of the port of Callao. Underinvestment in appropriate port equipment (gantry cranes, cranes, mobile dock and other equipment) is also an issue.

There are also problems with the access at the Callao port for trucks and specialized transport port. There are congestions in the central highway (that carries 80% of mineral concentrates produced). According to the Ministry of Transport, congestion level of the central road is 80% (i.e. the ratio volume to capacity is 0.8). The average speeds are only 10-20 km / hour. International standards indicate optimum speeds are between 40-50 km / hour.

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[22] http://go.worldbank.org/76DFAFZK10

[23] El Reto de la Infraestructura al 2018 "La Brecha de Inversión en Infraestructura en el Perú 2008". Document requested by the Association for the Promotion of National Infrastructure (AFIN).

[24] Supervisory Agency for Investment in Infrastructure Public Transportation.

Railway line is considered underutilized. Only 20% of the mining cargo is transported by this means of transport. Problems are related to the equipment operating in the Central Railway. The cars are not suitable for the transportation of minerals, but rather for grain transportation. This causes delays of about 20 minutes, where a wagon with automatic unloader can be unloaded in 4 or 5 minutes.

For air transport, Ositran noted there is a lack of cargo airlines with regular frequencies; not enough efforts by the Lima International Airport operator, Lima Airport Partners (LAP), in promoting cargo air freight transportation; and excessive costs and procedures imposed by LAP for the entry of cargo vehicles at Lima International Airport.

The Philippines

ALMEC (2008) provides a brief assessment of the present condition of transport infrastructure in the Philippines. Major ports for the international logistics include the Manila Port (North and South harbors), MICT, and Batangas Port. Manila port does not have sufficient handling capacity against the present demand, causing congestion. Alternatives at present are Batangas Port (south) and Subic Port (north). Investments are growing rapidly especially in Batangas area and some companies already started exporting by container from Batangas. Subic is likewise being developed. Domestic ports are not well suited for container operation, while Manila Port and Cebu port continues to have limitations in handling LOLO containers. In terms of roads, pavement ratio still remains around 21%, though it is influenced by tertiary roads (i.e. barangay roads). The primary road network is largely two-lane roads with relatively high roadside friction due to lack of access control. Maintenance has been improving but still insufficient. Major trunk lines include the North and South Luzon Expressways stretched from Manila. The South Luzon Expressway is not connected to Batangas (one of the major industrial areas that have a large port), a missing link, with the STAR Expressway. Traffic regulation on truck entry and by vehicle number plate is enforced in Metro Manila. The railway line in service is only for southern part of Luzon (Manila to Legazpi) and operational capacity is quite small. Railway container service commenced in 1997, connecting MICT to industrial area in south Manila, but is no longer operating. Railway ROW is littered with informal settlers, leading to high accident rates and inefficient operation. As for air connectivity, the major airports for the international logistics include Ninoy Aquino International Airport (NAIA), and Cebu International Airport. FedEX has relocated its operational hub for Asia-Pacific region from Subic Airport to Guangzhou, in south China.

World Bank (2009c) notes the key questions in transportation infrastructure are not about the number of facilities, but their effective capacity, the quality of the services they can provide, their location and how they work as a network. While the Philippines has sufficient number of transport infrastructure facilities the quality of those infrastructures prevent them from functioning optimally. For example, road density is on par with comparable economies in the region but road quality compares less well. The result is that the Philippines suffers from higher land transportation costs and a higher rate of accidents compared to other parts of the East Asia region. There are also many ports and airports across the islands but the airport capacity in Metro Manila is likely to come under pressure in the coming years. Also, the quality of railroad tracks and services is poor. The report recommends focus should be on upgrading the quality and capacity of existing ports, roads and airports rather than on expanding the coverage of transport networks. Also, to focus on upgrading the quality of railroad tracks and services and then – possibly – on expansion of the network.

Russian Federation

According to Pynnöniemi (2008), Russia is faced with the enormous task of modernizing its transport infrastructures. Systemic improvement in the roads, railways, inland waterways, and domestic air transport is needed as the economy needs a better integrated and more efficient transport system. Proper connections between the regions are an issue. In general, the infrastructure system is at its most dense in the European part of Russia where the majority of the population lives and the economy is most active. On the other hand, the base network in Siberia and the Russian Far East is not yet developed and some areas do not have connections to the main transport network. Air and inland-waterway transport have been under-financed, aggravating the imbalance between the European and Asian parts of the transport system. The rail system is of immense importance to the economy and some sections, about 30% of the main railway freight routes, can be regarded as bottlenecks. 60% of the Russian Railways' fixed assets and 80% of cargo wagons and diesel locomotives are old. For ports, the capacity to handle containers is not high relative to others, which partly explains why Russia accounts for only less than 1% of the cargo turnover between Europe and Asia or only 5-7% of its transit potential. The road network is also underdeveloped. Although the increase in traffic volumes is the immediate reason for the congestion along the main city and inter-city roads, the underlying cause is Russia's lack of normal roads. The bulk of the road traffic is concentrated in the federal roads, which account for about 5% of the total road length. Only 40% of the federal road network meets the criteria for 'normal' roads and this figure is even lower for the majority of roads that are under the remit of the regional and municipal authorities.

Some observers note that the overall infrastructure situation is improving especially at airports where important international events are being hosted. However, the road network remains a significant problem. Delivery to the Russian hinterland is quite difficult due to insufficient or poor quality roads. Ground transportation is a continuing challenge because only one railroad connects west and east throughout the year. Part of the reason for the lack of paved roads is the high cost of maintenance due to extreme weather conditions. The railway network is the main means of transport as it is the cheapest and most developed mode of transport. It accounts for 86% of freight transported while air and river, sea, and road account for less than 1%, 5%, and 8% respectively. ("Russia - Land of Infinite Infrastructure Possibilities," 2009)

Singapore

ALMEC (2008) provides a brief assessment of the present condition of transport infrastructure in Singapore. In terms of maritime connectivity, Singapore Port consists of PSA and Jurong Container Terminals. Around 80% of the cargo is transshipped. Port and cargo handling facilities are modern and their operation is quite efficient with advanced EDI system. Singapore port prioritizes mother vessel's operation, which sometimes causes delay of feeder vessel operation. The road condition is quite favorable. Traffic congestion is well-managed with traffic monitoring and road pricing schemes. Causeway and the Second Link are the connection to Malaysia. Since domestic market is so small, domestic transportation demands is also small. It is easy to handle domestic transportation smoothly because of its narrow land area. Regulation on the number of vehicles in Singapore contributes to good and smooth road condition. Singapore has no railway service, except for commuting lines (railway line is owned by Malaysian Railway). In terms of air connectivity, Changi International Airport has the most favorable cargo handling facilities, and continuously invests to expand the port handling capacity in preparation for future demand. In addition to the excellent airport facility, private logistics providers can easily have their own facility to provide their specific services. Speedy and transparent operation and procedure are highly appreciated.

Singapore's success in infrastructure development provides lessons for other economies. Lim (2007) offers the following recommendations based on Singapore's experience: (1) infrastructure development must have a long-term perspective, be based on economic viability, and managed on commercial-based practices, (2) in the initial stage, efficiency rather than equity should be the primary guideline, (3) the role and involvement of the private sector should be encouraged as the they often set the standard of efficiency and benchmark of quality and competitiveness, and (4) the principles of transparency and accountability should be practiced with respect to public tender for projects and management operation. The author also notes that Singapore's economic transformation would not have been possible if infrastructure development (hardware) were not undertaken simultaneously with public administration development (software).

Chinese Taipei

Jiang (2008) notes that Chinese Taipei has put much effort in road network construction. However, the lack of proper administration, coupled with a few local road-network bottlenecks, impedes the desired traffic capacity being achieved. Thus, Jiang suggests the government improve their own administrative strategies, such as implementing electronic levy charging system more widely, which is estimated to have, for example, the traffic capacity of Sun Yat-sen Highway increase by 25%. In terms of infrastructure projects, Huang (2008) identifies three major obstacles challenging Chinese Taipei's infrastructure projects. They are: (1) low attention to the essence of major infrastructures because of excessive number of infrastructure program; (2) a lack of reasonable evaluation methods to assess the achievement of each program; and (3) low attention to the financial resource or investment efficiency.

Thailand

ALMEC (2008) provides a brief assessment of the present condition of transport infrastructure in Thailand. There are five major ports in Thailand, of which two are operated by the Port Authority of Thailand namely, the Bangkok Port and the deep water port at Laem Chabang Port. The rest are the Phuket Port, the Map Ta Put port and the Songkhla Port. Most containerized cargoes had been transshipped over Singapore, partly because of the draft limitations that exist in the river port of Bangkok. However, since the commissioning of Laem Chabang, which is a deep-sea port, Thailand has begun to receive direct calls in the major East-West trades. Direct links between Thailand and other Asian economies, especially to China, have also developed greatly (there have been direct links to Japan for many years). The number of services connecting Thailand to other ASEAN ports has also increased. Laem Chabang port has become a major distribution hub for South China and neighboring Greater Mekong Sub-region (GMS). In terms of land connectivity, roads are generally in favorable condition and play an important role in domestic transport. With heavy traffic congestions in Bangkok, traffic regulations on truck are applied in the inner area of Bangkok Metropolitan during 6:00-21:00. Another truck restriction is also applied in all-staged expressway only during peak hours. Railways play a less important role in freight transport as it accounts for a small share of total freight. Most of goods transported by railway are low value and high weight, such as coal, petroleum products, cements, rice, sugar etc. The railway network is linked to Thailand's neighbors. With respect to air connectivity, major international airports include Bangkok, New Bangkok (Suvarnabhumi Airport), Chiang Mai, Chiang Rai, Hat-Yai, and Phuket. Major commodities of air transport are computer parts and accessories, electric equipment, precious stones and jewelry, and fruits and vegetables. The role of air transport has increased, with a share of about 10% of the net export value.

Pomlaktong and Ongkittikul (2007) raise three important issues in the transport infrastructure sector in Thailand within the context of achieving effective and balanced regional integration:

- Modal shift and intermodal transport issue - as Thailand's freight transport is dominated by road transport that is beset by problems like pollution and congestion, the Thai government has tried to enforce the policy to shift the road transport to more efficient and environmental-friendly modes, namely, railway and waterway. However, in order for the State Railway of Thailand (SRT) to be able to offer comparative advantages over competing modes of transport that are significant enough to influence the key players (e.g., shippers, freight forwarders, shipping companies, etc.) in their transport mode decision the railway sector as a whole has to be revitalized so that a series of legal, institutional, organizational, and infrastructural prerequisites are fulfilled.
- Cross-Border Transport Agreement for market integration – as part of the initiative to develop economic corridors in the GMS, a Cross Border Transport Agreement (CBTA) was devised. However, the implementation has been slow due to a host of issues which include lack of clarity on the impact, benefits, and distribution of benefits among the stakeholders as well as differences in transport regulations that much be addressed.
- Infrastructure pricing – In view of cross-border transport movement in the GMS, a systematic approach to infrastructure charging especially for heavy goods vehicles is required.

The United States

A study commissioned by the US National Chamber Foundation (2008) found that the large national backlog of needed capacity improvements and continuing underinvestment have contributed to declining transportation performance, which in turn affects the competitiveness of the US economy. Specifically, the poor performance of the US infrastructure is attributed to two factors: a growing imbalance between supply and demand and the increasing age of the nation's infrastructure where one-half of all bridges were built before 1964 and other transportation stock is aging quickly.

The effects of rapid growth in demand and limited growth in system capacity are reflected in increased congestion, increased freight transportation prices and less reliable trip times. Critically congested areas for business include the US-Canadian border between Ontario and

Detroit and the US-Mexican border at Loredo. With respect to individual modes, for highways it was found that urban interstate interchange bottlenecks accounted for most of the delay experienced by truckers. Railroads, which have had substantial surplus capacity in the rail network in the past, have experienced two decades of growth and major increases in rail traffic volumes. It is anticipated that many of the key national rail corridors supporting domestic and international trade will be facing severe capacity shortfalls in the coming years. Likewise, for US ports, studies surveyed by the report indicated that marine terminal capacity, navigation channels, and the associated highway and rail access to ports will not be able to meet future needs without significant levels of investment.

Various stakeholders interviewed highlighted the need for greater attention to the freight transportation system and advocated investments to fund critical freight corridor, gateway, and connector improvements. It was suggested that the US needs to be much more strategic in making critical investments so that transportation investment policy is linked to trade and economy policy. Finding effective institutional and financing approaches to deal with major interstate corridors and bottlenecks so that the benefits and costs could be shared among states was likewise recognized as an important challenge for the public and private sectors.

Viet Nam

ALMEC (2008) provides a brief assessment of the present condition of transport infrastructure in Viet Nam. The major ports include Hai Phong in the north and Saigon (including New Saigon, VICT) and Can Tho Ports in the south. Inland waterways also plays vital role in the county. Vietnam has 41,000 km of natural waterways, of which 8,000 km are used commercially. Vietnam stretches over 1,600 km along the eastern coast of the Indochina Peninsula. Most of population is concentrated in the two principal regions, namely southern Mekong Delta (including Ho Chi Minh City) and northern Red River Delta (including Hanoi). These regions are linked by National Highway No. 1. Urban areas of Hanoi and Ho Chi Minh City suffer from serious traffic congestion as well as main corridors like the National Highway No. 1. The total road length was 221,115 km in 2004. The road network carried 84% of passengers and 66% of freight in 2004. Container transport by rail is primitive and operated only by state-owned Vietnamese Railway Company. The long distance cargo delivery (North-South) is available but its reliability is insufficient. In terms of air connectivity, the major international airports include Ho Chi Minh City (Tan Son Nhat), Hanoi (Noi Bai) and Da Nang airports. The cargo handling capability in the air cargo terminal is considered inferior.

Thanh and Dapice (2009) citing international surveys note that infrastructure bottlenecks, rather than uncertain and complicated government policies, are now regarded as the biggest issue affecting the business environment. While financing is a serious factor, they argue that the most important infrastructure challenge facing Viet Nam is investment efficiency rather than inadequate levels of investment. The paper stressed that Viet Nam is now entering a stage of development that requires strategic investments in trunk transport infrastructure such as expressways, railways, seaports, and airports. They add that the location and composition of transport investment undertaken in the past and planned for the future do not seem to support the successful development of competitive industrial clusters, which is necessary for long-term growth.

A white paper prepared by the Transportation and Logistics Committee of the European Chamber of Commerce in Viet Nam (2009) highlighted the need to synchronize the different infrastructure types in order to increase the flow of goods throughout the whole supply chain. Specific recommendations are also provided which include: further access channel clearing for Cai Mep/Thi Vai ports in order to accommodate ships longer than 300 meters, additional warehousing space for cargo handling in the airports, enlargement of cargo rail system for linking ports with key economic areas, light signal systems for all waterways and access channels in order to cope with the growing barging traffic, improving road quality and separating trucking from motorbike traffic, etc.

B. TECHNICAL ANNEX

This section provides additional detail on the gravity model and estimation results discussed in the main text.

Specification of the Gravity Model

The starting point for the analysis is a gravity model based on standard theories of international trade (Anderson & Van Wincoop 2003, 2004).[25] It takes the following form:

$$(1)\ \log\left(X_{ij}^{k}\right) = \log\left(E_j^k\right) + \log\left(Y_i^k\right) - \log\left(Y^k\right) + (1-s)\log\left(t_{ij}^k\right) - (1-\sigma)\log\left(P_j^k\right) - (1-s)\log\left(\Pi_i^k\right) + e_{ij}$$

where: X_{ij} is exports from economy *i* to economy *j* in sector *k*; E_j is sectoral expenditure in economy *j*; Y_i is sectoral production in economy *i*; t_{ij}^k is bilateral trade costs; *s* is the intra-sectoral elasticity of substitution (between varieties within a sector); and e_{ij} is a random error term satisfying standard assumptions. The P_j^k and Π_i^k terms represent multilateral resistance, i.e. the fact that trade patterns are determined by the level of bilateral trade costs relative to trade costs elsewhere in the world. Inward multilateral resistance $(P_j^k)^{(1-s)} = \sum_{i=1}^{N}\left(\Pi_i^k\right)^{(s-1)} w_i \left(t_{ij}^k\right)^{(1-s)}$ captures the dependence of economy *j*'s imports on trade costs across all suppliers. Outward multilateral resistance $(\Pi_i^k)^{(1-s)} = \sum_{i=1}^{N}\left(P_j^k\right)^{(s-1)} w_j \left(t_{ij}^k\right)^{(1-s)}$ captures the dependence of economy *i*'s exports on trade costs across all destination markets. The *w* terms are weights equivalent to each economy's share in global output or expenditure.

Ideally, empirical work based on equation (1) should fully account for multilateral resistance, for example by using fixed effects. This is not possible in the present case, however, since the analysis is focused on data that vary by exporting economy but not across importers for a given exporter. Indicators of multimodal transport performance would be perfectly collinear with exporter fixed effects, and the model therefore could not be estimated.

[25] In addition to the variables listed here, early gravity models often included per capita GDP as an additional regressor. We exclude it because recent gravity theories do not provide any sound basis for including it. Current best practice, as reflected in a variety of peer-reviewed journal articles, is to include aggregate GDP only. For examples, see: Anderson & Van Wincoop (2003, 2004); Chaney (2008); and Helpman et al. (2008).

A second-best estimation option is to use fixed effects to account for inward multilateral resistance, and random effects for outward multilateral resistance (equation 2). The random effects specification puts more structure on the data than fixed effects, since it assumes that outward multilateral resistance can be adequately summarized by a random variable that follows a normal distribution; a fixed effects specification allows for unconstrained variation. The mixed effects model with fixed effects by importer and random effects by exporter represents an acceptable compromise in this case between research objectives and empirical rigor.

$$(2)\ \log\left(X_{ij}^{k}\right) = \mathrm{r_i} + \log\left(Y_i^k\right) + \mathrm{f_j} - \log\left(Y^k\right) + (1-s)\log\left(t_{ij}^k\right) + e_{ij}$$
$$r \sim N(0, v)$$

The final part of the model is the trade costs function *t*. The basic specification (equation 3) includes the indicators of maritime, air, and logistics performance discussed in the main text. It also includes standard gravity model control variables such as distance (a proxy for transport costs), tariffs, colonial connections, common language, and APEC membership of the exporting and importing economies jointly.

$$\begin{aligned}(3)\ \log\left(t_{ij}\right) = {} & b_1 \log(sea_i) + b_2 \log(air_i) + b_3 \log(\mathrm{land_i}) + \mathrm{b_4}\log(logistics_i) \\ & + b_5 \log\left(distance_{ij}\right) + b_6 tariff_{ij} + b_7 APEC_{ij} + b_8 border_{ij} \\ & + b_9 language_{ij} + b_{10} colony_{ij} + b_{11} colonizer_{ij}\end{aligned}$$

To estimate the model, we substitute equation (3) into equation (2) and proceed using the standard OLS estimator. The presence of zeros in the bilateral trade matrix—132 out of 3790 observations for total trade—means that we need to adjust the export data by adding one prior to taking the logarithm. Due to the relatively small number of zeros, it is not informative to apply alternative methodologies such as the Heckman sample selection model (Helpman et al. 2008) or the Poisson estimator (Silva & Tenreyro 2006).

Data Sources

For the most part, the gravity modeling work presented here uses standard data sources. Table 7 provides a full summary.

Export data are taken from UN Comtrade accessed via the World Bank's WITS platform, and cover total exports and exports by one digit sector following the Broad Economic Classification system. For Chinese Taipei, export data come from SourceOECD. For convenience, BEC sectors one and three (food and fuels) are aggregated into a single sector, as are sectors four and five (capital goods and transport equipment), and sectors six and seven (consumer and other goods).

Tariff data are from UNCTAD's TRAINS database, accessed via WITS. Tariff rates are effective bilateral rates that take account of regional and preferential trade agreements. They are averaged by applying trade weights.

The model also includes standard gravity model controls such as the distance between economies, colonial history, and common language. All such variables come from CEPII's distance database (http://www.cepii.fr/anglaisgraph/bdd/distances.htm).

Analyzing the effects of multimodal transport capabilities on trade requires additional data. For maritime transport, we use UNCTAD's Liner Shipping Connectivity Index (LSCI). It is a weighted average (first principal component) of the five underlying indicators: the number of ships; their container carrying capacity; the maximum vessel size; the number of services; and the number of companies that deploy containerships on services to or from an economy's ports.

Box: Principal Components Analysis

We make repeated use of principal components analysis (PCA) to produce summary indicators of multimodal transport performance. PCA is a standard statistical technique used to reduce the dimensionality of a dataset; in other words, it summarizes the information in a set of indicators using a smaller number of indicators (principal components).

The inputs for PCA are the underlying indicators, normalized by subtracting the sample mean and dividing by the standard deviation so that all variables have mean zero and unit standard deviation. The output from PCA is a single indicator—such as the multimodal transport indicator—that summarizes performance across the range of indicators used as inputs. Each principal component is a weighted average of the underlying indicators, with the weights chosen so as to maximize the proportion of sample variance accounted for by the principal component.

PCA is widely used in the transport connectivity field, for example by UNCTAD's LSCI and the World Bank's Logistics Performance Index. Previous applications of PCA in the context of trade facilitation include Helble et al. (2009).

There is no comparable indicator available for air transport. By analogy with the LSCI, the model includes an air transport index, which is a weighted average (first principal component) of the number of primary and secondary airports (source: *CIA World Factbook*). The summary air transport indicator accounts for over 90% of the variation in the original set of indicators.

Land transport also lacks a summary performance indicator. We adopt the same approach as in the previous paragraph. The PCA covers road and rail density, measured as the length of each network relative to an economy's land area. Both measures are sourced from the *CIA World Factbook*, and the *World Development Indicators*. The first principal component of these indicators accounts for around 70% of the variation in the original data.

The World Bank's *Logistics Performance Index* provides a comprehensive, cross-economy reference on supply chain performance. The LPI itself is the first principal component of six underlying dimensions of logistics performance: efficiency of the clearance process; quality of trade and transport infrastructure; ease of arranging competitively priced shipments; competence and quality of logistics services; ability to track and trace consignments; and timeliness of delivery. We use one of these dimensions—the competence and quality of logistics services—as an indicator of an economy's ability to coordinate complex multimodal transport operations.

The final source is an index of overall multimodal transport performance. It is a weighted average (first principal component) of the indices for air, maritime, and land transport, and logistics competence. The summary index accounts for over half of the variation in the four original indices.

Detailed results from the principal components analyses for air transport, land transport, and overall multimodal performance are set out in Table 8. The table presents loading factors for each component, i.e. the weight accorded to each indicator in constructing the summary measure.

Table 7 Data and sources

Variable	Description	Year	Source
Air Transport	First principal component of the following indicators: the number of primary and secondary airports.	2007	CIA World Factbook.
APEC	Dummy variable equal to unity if both economies are APEC member economies.	n/a	n/a
Colony	Dummy variable equal to unity if one economy was once a colony of the other.	n/a	CEPII.
Common Border	Dummy variable equal to unity for economies that share a common land border.	n/a	CEPII.
Common Colonizer	Dummy variable equal to unity for economies that were colonized by the same power.	n/a	CEPII.
Common Language	Dummy variable equal to unity for economies that share a language spoken by more than 9% of the population.	n/a	CEPII.
Distance	Great circle distance between the main cities of economies *i* and *j*, weighted by internal distance	n/a	CEPII.
Exports	Total and BEC 1-digit exports from economy *i* to economy *j*.	2007	Comtrade via WITS; SourceOECD.
GDP	Nominal GDP in USD.	2007	World Development Indicators.
Land Transport	First principal component of the following indicators: road network length / land area; and rail network length / land area.	2007	CIA World Factbook; and World Development Indicators.
Logistics	Logistics Performance Index score on the competence and quality of logistics services.	2007	World Bank.
Maritime Transport	Liner Shipping Connectivity Index score.	2007	UNCTAD.
Multimodal Transport	First principal component of: Air Transport; Land Transport; Logistics; and Maritime Transport.	2007	Own calculations
Population Density	Population density (population per square km.).	2007	World Development Indicators
Tariff Rate	Effectively applied tariff, trade weighted average.	2007	TRAINS via WITS.

Table 8 Results of principal components analysis

Air Transport		Land Transport		Multimodal Transport	
Variable	**Loading**	**Variable**	**Loading**	**Variable**	**Loading**
Number of primary airports	0.7071	Road network density	0.7071	Air Transport	0.2048
Number of secondary airports	0.7071	Rail network density	0.7071	Land Transport	0.5336
				Logistics	0.6081
				Maritime Transport	0.5510

Note: Eigenvalues for the first principal components are 1.9, 1.4, and 2.03 respectively.

Empirical Results using Total Trade

We start by estimating the gravity model using data on total exports from APEC members to up to 229 overseas markets. Results are in Table 9. The first two columns provide baseline results for comparative purposes, and exclude data on multimodal transport performance.

Column 1 estimates the gravity model using fixed effects by exporter and by importer, in a way that is fully consistent with theory (Anderson & Van Wincoop 2003, 2004).[26] Column 2 re-estimates the same model using fixed effects by importer and random effects by exporter, as discussed above.

Both models give results that accord with the general gravity model literature. The coefficients on GDP, APEC, common language, and colonial history, are all positive and statistically significant. The common border has a statistically significant coefficient in column 2 only. The coefficients on distance and tariffs are negatively signed, and both statistically significant in column 1. In column 2, only distance has a statistically significant coefficient.

Although there are some differences in estimated coefficients between the models in columns 1-2, they are generally quite minor. The similarity in the two sets of estimates confirms that it is appropriate to continue with the mixed effects model as an approximation to the true, theoretically-grounded model. The largest difference between the two sets of estimates is in relation to the APEC coefficient, which is positive and statistically significant in both specifications, but has a much larger coefficient in the mixed effects regression. One possible reason for the difference is close correlation between the APEC variable and the fixed effects, since it is the multiple of each economy's APEC membership.

Columns 3-8 present results using the augmented gravity model. Each column introduces a different variable or set of variables measuring multimodal transport. Column 3 includes maritime transport only, and the estimated coefficient is positive and statistically significant, which indicates that improved maritime links have the potential to boost APEC member economies' trade. Columns 5 and 6 find similar results for land transport, and logistics competence: both estimated coefficients are positive and statistically significant. In column 4, however, the coefficient on air transport is positive, as expected, but it is not statistically significant.

Results in columns 3-6 should be interpreted cautiously due to omitted variable bias: in each case, only one multimodal transport indicator is included in the regression. In column 7, the model is augmented to include all four multimodal transport indicators simultaneously, and thus avoid the bias problem in the previous results. Results in this case are similar to columns 3-6 for maritime transport, land transport, and logistics performance: they all have coefficients that are positive and at least 5% significant. In addition, the coefficient on air transport is now positive and statistically significant (1%), which is in line with expectations. This result highlights the importance of including all variables together for all but preliminary, exploratory regressions.

The regression results in column 7 allow us to say something about the relative sensitivity of APEC trade flows to the various dimensions of multimodal transport performance. The variable with the strongest impact is logistics competence: a one point increase in our index, where 100 represents the regional leader, is associated with an impact effect on trade of 2.3%. The variable with the next strongest impact is maritime transport, however it is around half as strong as that of logistics competence. A one point increase in the maritime transport index is associated with a trade increase of just over 1%. Next in line comes air transport, with an

[26] GDP is excluded from this regression because of perfect collinearity with the fixed effects. Such an approach is standard in the gravity model literature based on the Anderson and Van Wincoop model.

effect just slightly weaker than that of maritime transport. Land transport has the weakest effect, with a one point increase in the index being associated with a 0.5% increase in trade.

Next, we run an additional regression using the index of multimodal transport discussed above, i.e. a principal component weighted average of the other four indices (maritime transport, land transport, air transport, and logistics competence). The reason for aggregating the indices in this way for regression purposes is twofold. First, it takes account of the strong correlations between them, which can lead to inflated standard errors. Second, it provides a more robust basis for counterfactual simulations (see below), since it eliminates double counting of performance improvements that might otherwise take place due to the strong correlations among indicators.

Results in column 8 are fully in line with expectations. The multimodal transport indicator has a positive and 1% significant coefficient. Its magnitude is greater than those of any of the individual transport modes in column 7. Concretely, an improvement in overall multimodal transport performance that brings an economy one point closer to the regional leader is associated with an export increase of around 3%. This result again suggests that overall performance is strongly influenced not just by performance in each mode, but also by the ability to make each mode work efficiently and effectively with the others.

Reverse causality is clearly an issue in this model due to the possibility of a virtuous cycle between trade and multimodal transport performance. Column 9 confronts this problem using the statistical methodology of instrumental variables, or two-stage generalized least squares (2GSLS). The 2GSLS estimator uses an external variable—the instrument—to purge multimodal transport performance of the causal influence that trade flows might exert on it. The instrument must be strongly correlated with multimodal transport, but must not affect trade through any other variable in the model. In this case, we use population density as an instrument. We expect economies with higher population densities to have better multimodal transport performance because geographical agglomeration makes it easier for different modes to work together, and also makes infrastructure development less expensive due to the need to cover less territory. The data strongly support this contention: the first stage coefficient on population density is 6.744*** ($z = 53.19$). Since there is no other way that population density can affect trade flows, we expect it to satisfy both criteria for instrument validity.

Column 9 presents results from the second stage of the 2GSLS regression. The coefficient on multimodal transport is smaller in magnitude, but it remains 1% statistically significant. A fall in the value of the coefficient is exactly what we would expect from a “virtuous cycle” causal dynamic involving trade and multimodal transport performance. Based on the 2GSLS results—which are the most robust ones available—a one point increase in the multimodal transport index is associated with a trade increase of around 1%.

Table 9 Gravity model regression results using data on total exports

Model: Dependent Variable:	(1) Fixed Effects Log (1+Exports)	(2) Comparison Log (1+Exports)	(3) Maritime Log (1+Exports)	(4) Air Log (1+Exports)	(5) Land Log (1+Exports)	(6) Logistics Log (1+Exports)	(7) All Log (1+Exports)	(8) Multimodal Log (1+Exports)	(9) 2GSLS Log (1+Exports)
Maritime Transport			0.023*** (0.000)				0.012*** (0.000)		
Air Transport				-0.003 (0.280)			0.009*** (0.002)		
Land Transport					0.019*** (0.000)		0.005** (0.019)		
Logistics Competence						0.030*** (0.000)	0.023*** (0.000)		
Multimodal Transport								0.032*** (0.000)	0.010*** (0.009)
Log(GDP)		0.947*** (0.000)	0.778*** (0.000)	0.976*** (0.000)	0.853*** (0.000)	0.806*** (0.000)	0.641*** (0.000)	0.657*** (0.000)	0.861*** (0.000)
Log(Distance)	-1.703*** (0.000)	-1.560*** (0.000)	-1.558*** (0.000)	-1.563*** (0.000)	-1.578*** (0.000)	-1.809*** (0.000)	-1.747*** (0.000)	-1.688*** (0.000)	-1.598*** (0.000)
Tariff Rate	-0.016* (0.076)	-0.016 (0.145)	-0.007 (0.504)	-0.016 (0.145)	-0.007 (0.516)	0.018* (0.061)	0.018* (0.067)	0.013 (0.169)	-0.007 (0.466)
APEC	9.901*** (0.001)	3.734*** (0.000)	3.785*** (0.000)	3.737*** (0.000)	3.606*** (0.000)	3.197*** (0.000)	3.303*** (0.000)	3.400*** (0.000)	3.635*** (0.000)
Common Language	0.621*** (0.000)	0.395** (0.014)	0.435*** (0.006)	0.409** (0.012)	0.455*** (0.004)	-0.040 (0.794)	0.058 (0.716)	0.224 (0.139)	0.344** (0.028)
Common Border	0.369 (0.244)	0.705*** (0.009)	0.632** (0.016)	0.704*** (0.009)	0.924*** (0.001)	1.043*** (0.000)	0.993*** (0.000)	0.993*** (0.000)	0.791*** (0.005)
Common Colonizer	0.746*** (0.000)	0.868*** (0.001)	0.096 (0.727)	0.875*** (0.001)	0.648*** (0.009)	0.344 (0.188)	-0.016 (0.953)	-0.004 (0.988)	0.608** (0.021)
Colony	1.968*** (0.000)	1.308*** (0.001)	1.628*** (0.000)	1.319*** (0.001)	1.302*** (0.001)	1.591*** (0.000)	1.660*** (0.000)	1.604*** (0.000)	1.396*** (0.000)
Obs.	3262	3124	3124	3124	3124	3124	3124	3124	3124
R^2	0.754	0.638	0.649	0.638	0.645	0.656	0.659	0.657	0.648

χ^2 or F	47.906***	8370.949***	7694.176***	8328.907***	8291.500***	7537.634***	7853.846***	7940.259***	16718.74***
Fixed Effects	Importer Exporter	Importer	Importer	Importer	Importer	Importer	Importer	Importer	Importer
Random Effects		Exporter	Exporter	Exporter	Exporter	Exporter	Exporter	Exporter	Exporter

Note: Estimation is by OLS and GLS in columns 1-8, and 2GSLS in column 9. Standard errors are robust, and adjusted for clustering by reporter, except in column 9 where they are bootstrapped (500 replications). The estimated coefficient on the excluded instrument in the first stage 2SLS regression is 6.744*** (z = 53.19). Prob. values are in parentheses below the coefficient estimates. Statistical significance is indicated by: * 10%, ** 5%, and *** 1%.

Counterfactual ("What If?") Simulations

To express the regression results in a different way, we also conduct counterfactual simulations. We look at the trade impacts of improving multimodal transport performance in all APEC member economies. We assume that they act in a concerted way, i.e. all economies undertake similar reforms simultaneously.

Gravity model counterfactuals need to be conducted carefully to make sure that they properly account for changes in multilateral resistance. Failure to account for these effects can lead to serious upward bias in the estimates of gains from reform. We therefore adopt a different technique from previous work on trade facilitation (e.g., Wilson et al. 2005), which does not account for multilateral resistance in their counterfactual analysis. We use the estimated 2SLS parameters from the mixed effects regression model (Table 9 column 9), but we undertake the counterfactual analysis using the approximation of the exporter's multilateral resistance term introduced by Baier and Bergstrand (2009):

$$\log P_i^{(1-\sigma)} \approx (s-1)\left[\sum w_j \log t_{ij} - \frac{1}{2}\sum\sum w_i w_j \log t_{ij}\right]$$

Proceeding in this way provides more accurate simulation results for the case of concerted reform than does applying the regression coefficients directly to counterfactual values of trade facilitation variables. As Anderson & Van Wincoop (2003) and Baier & Bergstrand (2009) show, the difference can be quantitatively important. In general, results obtained using the present methodology show smaller trade gains from a given level of reform than do those obtained using the Wilson et al. (2005) approach. However, the simulation only takes account of reform and multilateral resistance on the export side. It does not consider changes in import policies or behavior. The reason for this is that the focus on this paper is on exports, and so the regression models are constructed with importer fixed effects to account for multimodal transport performance on the import side, rather than including data directly. It is not possible to undertake counterfactuals based on the fixed effects themselves.

Empirical Results by Sector

Table 10 presents results for the same gravity model as in column 7 of Table 9, but using data disaggregated by sector. The sectoral classification follows the one digit level of the Broad Economic Classification system (BEC). Looking across the columns of Table 10 makes it possible to obtain a first idea of which sectors are particularly sensitive to the performance of each transport mode.

Maritime transport plays an important role in exports of consumer goods, capital goods, and industrial supplies. Air transport is especially important for exports of food, and to a lesser extent consumer and other goods, and industrial products. Land transport appears to be particularly important for exports of transport equipment. The most consistent results from any of the four indicators come from logistics competence. It is a significant determinant of trade performance in all sectors.

A number of results in Table 10 are inconsistent with expectations, however, in that the estimated coefficients on some of the multimodal transport indicators have coefficients that are negative and, in some cases, statistically significant. Where coefficients are not significant, the effect of the transport mode in question can be considered to be negligible for the sector in that regression. Where coefficients are significant, there are two possible explanations for the model's poor performance. First, samples are in some cases very small—as low as 679 observations, compared with over 3,000 for the aggregate trade regressions. The reason for this change in sample size is that not all economies trade all types of goods with all other economies. An additional problem with these regressions is that the BEC is a very broad classification that arguably groups together products that do not necessarily behave the same way in the context of trade and transport analysis. Future work could explore this point further by using a different classification system that is more homogeneous, such as ISIC.

Table 10 Gravity model regression results using disaggregated export data

	(1) Food & Beverages	(2) Industrial Supplies	(3) Fuels & Lubricants	(4) Capital Goods	(5) Transport Equipment	(6) Consumer Goods	(7) Other Goods
Maritime Transport	-0.021***	0.011***	-0.034***	0.029***	0.007	0.058***	-0.012*
	(0.000)	(0.003)	(0.000)	(0.000)	(0.279)	(0.000)	(0.082)
Air Transport	0.067***	0.007**	0.012	-0.006	-0.013**	0.012***	0.016**
	(0.000)	(0.038)	(0.198)	(0.107)	(0.010)	(0.001)	(0.012)
Land Transport	-0.069***	-0.005	-0.043***	-0.004	0.047***	-0.007**	0.003
	(0.000)	(0.100)	(0.000)	(0.181)	(0.000)	(0.015)	(0.611)
Logistics Competence	0.063***	0.009**	0.037***	0.040***	0.011*	0.028***	0.065***
	(0.000)	(0.025)	(0.003)	(0.000)	(0.078)	(0.000)	(0.000)
Log(GDP)	-0.272***	0.926***	2.210***	1.109***	1.914***	0.353***	1.185***
	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log(Distance)	-2.262***	-2.166***	-4.689***	-2.438***	-2.551***	-2.649***	-1.635***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tariff Rate	0.010***	-0.009	0.027	0.001	0.081***	0.074***	0.046*
	(0.003)	(0.522)	(0.730)	(0.978)	(0.000)	(0.000)	(0.036)
APEC	3.386***	6.205***	-0.788	3.807***	3.602**	2.911***	12.738***
	(0.000)	(0.000)	(0.877)	(0.000)	(0.014)	(0.000)	(0.000)
Common Language	-0.077	-0.035	-0.760	0.181	0.555*	0.556***	-0.329
	(0.753)	(0.858)	(0.170)	(0.348)	(0.074)	(0.003)	(0.440)
Common Border	0.635	0.770**	1.466*	0.302	0.698	-0.075	2.005**
	(0.163)	(0.036)	(0.097)	(0.431)	(0.204)	(0.849)	(0.006)
Common Colonizer	-0.896	-0.296	3.380**	-1.071**	-0.295	-0.158	1.863**
	(0.133)	(0.458)	(0.013)	(0.023)	(0.732)	(0.644)	(0.021)
Colony	1.976***	2.041***	1.127	1.900***	1.789***	2.534***	0.374
	(0.000)	(0.000)	(0.374)	(0.000)	(0.006)	(0.000)	(0.612)
Observations	2306	2799	1023	2585	1825	2537	679
R^2	0.505	0.626	0.541	0.652	0.559	0.656	0.614
χ^2	n/a	n/a	n/a	5497.932***	n/a	163943.629***	n/a
Fixed Effects	Importer	Importer	Importer	Importer	Importer	Importer	Importer
Random Effects	Exporter	Exporter	Exporter	Exporter	Exporter	Exporter	Exporter

Note: Dependent variable is log(1+Exports). Estimation is by GLS. Standard errors are robust, and adjusted for clustering by reporter. Prob. values are in parentheses below the coefficient estimates. Statistical significance is indicated by: * 10%, ** 5%, and *** 1%.

Another reason that some results in Table 10 do not accord with expectations is that the strong correlation among the four multimodal transport indicators results in imprecise estimates. To remedy this problem, we repeat the regressions using the overall multimodal transport indicator (Table 11).

As expected, results are more consistent. Five of the seven regressions have a multimodal transport coefficient that is positively signed and statistically significant; only for fuels and lubricants, and food and beverages, does the coefficient have an unexpected and statistically significant sign. The reasons for these unexpected results are again likely to be a combination of sample size and lack of homogeneity in the product classification, as well as the fact that trade in agricultural products is subject to a range of non-tariff measures that are not easily captured in a gravity regression. Similarly, exports of fuels and lubricants are subject to the dynamics of international commodity markets in a way that is not easily captured in a gravity model framework

The magnitude of the coefficient on multimodal transport performance varies from one regression to another. This again reflects the fact that different sectors respond differently to improvements. The sensitivity of trade to multimodal transport is particularly strong in the consumer goods sector, followed by capital goods, transport equipment, other goods, and industrial supplies.

Table 11 Gravity model regression results using disaggregated export data (continued)

	(1) Food & Beverages	(2) Industrial Supplies	(3) Fuels & Lubricants	(4) Capital Goods	(5) Transport Equipment	(6) Consumer Goods	(7) Other Goods
Multimodal Transport	-0.018**	0.013***	-0.029**	0.055***	0.049***	0.062***	0.048***
	(0.002)	(0.000)	(0.007)	(0.000)	(0.000)	(0.000)	(0.000)
Log(GDP)	0.395***	0.988***	2.319***	0.942***	1.634***	0.455***	1.162***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log(Distance)	-1.684***	-2.146***	-4.277***	-2.324***	-2.624***	-2.689***	-1.127***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tariff Rate	-0.000	-0.009	-0.052	0.007	0.079***	0.074***	0.024
	(0.936)	(0.549)	(0.471)	(0.814)	(0.000)	(0.000)	(0.307)
APEC	3.441***	6.192***	-0.661	3.851***	3.662*	2.724***	12.522***
	(0.000)	(0.000)	(0.891)	(0.000)	(0.026)	(0.000)	(0.000)
Common Language	1.681***	0.071	-0.029	0.399*	0.211	0.647***	0.154
	(0.000)	(0.697)	(0.956)	(0.030)	(0.477)	(0.001)	(0.711)
Common Border	0.471	0.864*	1.223	0.456	0.513	0.350	1.963**
	(0.290)	(0.019)	(0.151)	(0.226)	(0.351)	(0.395)	(0.010)
Common Colonizer	-0.575	-0.149	3.275*	-0.956*	-0.651	0.476	1.706*
	(0.330)	(0.700)	(0.015)	(0.037)	(0.457)	(0.137)	(0.035)
Colony	1.854***	1.956***	0.969	1.619**	2.018**	2.098***	0.532
	(0.000)	(0.000)	(0.446)	(0.001)	(0.002)	(0.000)	(0.471)
Observations	2306	2799	1023	2585	1825	2537	679
R^2	0.422	0.624	0.528	0.644	0.550	0.629	0.590
χ^2	n/a	n/a	n/a	5629.055***	n/a	134301.896***	n/a
Fixed Effects	Importer	Importer	Importer	Importer	Importer	Importer	Importer
Random Effects	Exporter	Exporter	Exporter	Exporter	Exporter	Exporter	Exporter

Note: Dependent variable is log(1+Exports). Estimation is by GLS. Standard errors are robust, and adjusted for clustering by reporter. Prob. values are in parentheses below the coefficient estimates. Statistical significance is indicated by: * 10%, ** 5%, and *** 1%.