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MEASURING TRANSPORT CONNECTIVITY FOR TRADE IN ASIA

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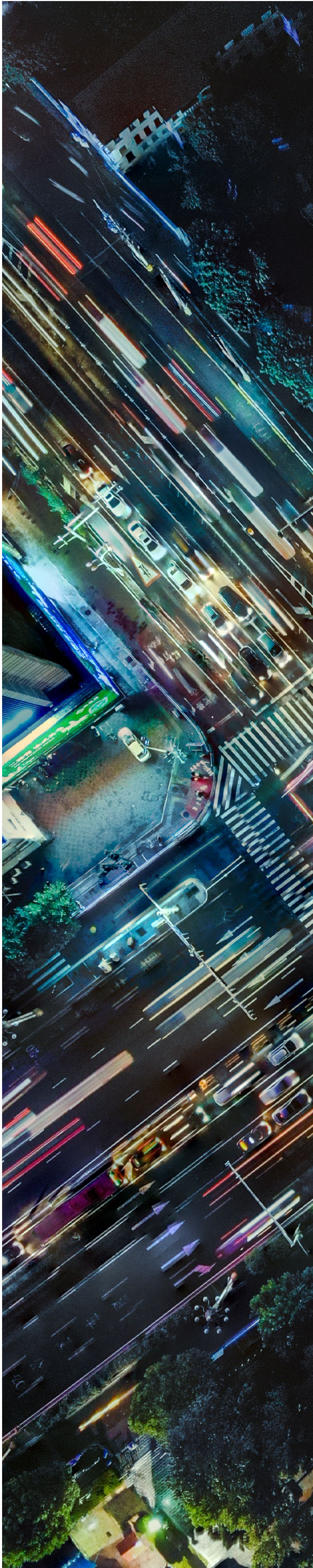
CONTENTS



LIST OF TABLES, FIGURES AND BOXES

TABLES

FIGURES

COUNTRY ABBREVIATIONS

ISO 3 country code	Country	AIIB Member
AFG	Afghanistan	Afghanistan
ARE	United Arab Emirates	United Arab Emirates
ARM	Armenia	
AZE	Azerbaijan	Azerbaijan
BGD	Bangladesh	Bangladesh
BGR	Bulgaria	
BLR	Belarus	Belarus
BRN	Brunei	Brunei Darussalam
BTN	Bhutan	
CHN	China	China
DEU	Germany	Germany
EGY	Egypt	Egypt
EST	Estonia	
GEO	Georgia	Georgia
GRC	Greece	Greece
IDN	Indonesia	Indonesia
IND	India	India
IRN	Iran	Iran
IRQ	Iraq	
ISR	Israel	Israel
JOR	Jordan	Jordan
KAZ	Kazakhstan	Kazakhstan
KGZ	Kyrgyz Republic	Kyrgyz Republic
KHM	Cambodia	Cambodia
KOR	South Korea	Korea
KWT	Kuwait	
LAO	Laos	Lao PDR
LBN	Lebanon	
LTU	Lithuania	
LVA	Latvia	
MMR	Myanmar	Myanmar
MNG	Mongolia	Mongolia
MYS	Malaysia	Malaysia
NLD	Netherlands	Netherlands
NPL	Nepal	Nepal
OMN	Oman	Oman
PAK	Pakistan	Pakistan
POL	Poland	Poland
QAT	Qatar	Qatar
RUS	Russia	Russia
SAU	Saudi Arabia	Saudi Arabia
SGP	Singapore	Singapore
SYR	Syria	
THA	Thailand	Thailand
TJK	Tajikistan	Tajikistan
TKM	Turkmenistan	
TUR	Turkey	Turkey
UZB	Uzbekistan	Uzbekistan
VNM	Vietnam	Viet Nam
YEM	Yemen	

ABOUT THE REPORT

Measuring Transport Connectivity for Trade in Asia was commissioned by the Asian Infrastructure Investment Bank (AIIB) as an annex to *Asia Infrastructure Finance 2021: Sustaining Global Value Chains*, the AIIB's annual flagship publication. It employs geospatial techniques to understand transport infrastructure development in Asia and the link between connectivity and global value chains. The report was written by The Economist Intelligence Unit (EIU), which is solely responsible for the content of this report. The EIU research team includes Liu Weisi, Tang Jie, Minakshi Barman and Alexander van Kemenade.

EXECUTIVE SUMMARY

Asia has made significant strides in building its physical transport network in recent decades. At the same time, businesses in the region have accelerated their integration into global value chains. However, significant infrastructure imbalances remain across the region and present obstacles for international trade to realise its full potential in boosting economic growth.

This report employs novel geospatial techniques to measure transport connectivity in AIIB member countries, focusing on road and seaport connections. These new measures give rise to the following findings:

- There is substantial variation in domestic road connectivity across countries, with the highest-scoring (China and the Gulf states) performing on par with or even exceeding the best-connected countries in Europe, such as Germany and the Netherlands.
- Countries experiencing lagging connectivity, such as Kyrgyzstan and Bangladesh, tend to be challenged by either rugged terrain or the presence of large rivers. Yet, well-targeted infrastructure projects, such as Bangladesh's Padma Bridge, carry the potential to significantly boost these countries' connectivity scores.
- Highway networks are the main missing ingredient in Asia's road connectivity, with highways forming the most important determinant of a country's connectivity score. National highway networks range from relatively comprehensive to non-existent.
- Cross-border road connectivity between Asian countries is significantly behind that found in more developed regions such as Europe. Only two cross-border highway connections are currently in place (Malaysia-Singapore and China-Vietnam).
- Improving road connections between ports and industrial clusters has the potential to boost participation in global value chains. Landlocked countries, or those with significant industrial activity in non-coastal areas, such as Laos, Cambodia, Georgia and Bangladesh, stand to benefit significantly from reduced travel time to ports.

The report explores the links between trade, economic development and connectivity. Income is positively correlated with road connectivity. Seaports with surrounding road connections to industry play a more prominent role in trade. Special Economic Zones with shorter travel times to airports and seaports also export more. Countries with better cross-border road connections tend to trade more with each other.

Further analysis of the causal relationship between infrastructure and economic growth would provide greater confidence and accuracy in the economic implications of improving road connectivity. This report presents the possibilities for generating insights using new data and tools to assess connectivity. Such insights may provide a useful future basis for policymakers in Asia to engage in infrastructure planning.

INTRODUCTION

Transport connectivity is essential for trade in physical goods. As increasing specialisation of tasks across countries creates ever-more-complex international supply chains, the need for seamless connectivity has never been greater. At the same time, the emergence of better digital datasets on global transport infrastructure, coupled with faster software and computing capabilities, is enabling the study of transport connectivity to an unprecedented degree.

This section of the Asia Infrastructure Finance (AIF) report focuses on using geospatial datasets to build a deeper understanding of transport connectivity across Asia, particularly as it pertains to global trade. The analysis primarily aims to compile new data and calculate new measures of connectivity, focusing on the Asian Infrastructure Investment Bank's (AIIB) regional member countries. A secondary objective is to explore linkages between connectivity and trade. The emphasis is on assessing:

1. **Road connectivity:** Roads remain the arteries of global transport, yet little is understood about road connectivity across and within country borders in Asia. New measures of cross-border and domestic road connectivity in Asia are constructed. The potential impact of new road improvements is illustrated with a case study on Bangladesh's bridges.
2. **Port access and connectivity:** As the main conduits of international trade, access to seaports is a critical component for a country's participation in global value chains. New country-level measures of port connectivity are constructed with a view to understanding where improved road connections to ports can benefit firms, with a special focus on India's ports.
3. **Special economic zones (SEZs):** For many countries, SEZs are an important policy tool used to accelerate industrial and infrastructure development in a targeted region. A new spatial dataset on SEZs is presented and links between various forms of transport infrastructure and SEZ exports are explored in a case study on China.

The analysis presented in the following sections is largely descriptive, seeking to paint an Asia-wide portrait of transport connectivity. The authors hope it provides a starting point for policymakers to assess transport infrastructure needs, and how such infrastructure may facilitate participation in global value chains, rather than presenting strong recommendations for new infrastructure investment. Every country and region will have economic, social, and environmental nuances that should be considered in much greater depth before undertaking any individual project.

METHODOLOGY

Traditional measures of connectivity tend to rely on density-based concepts, such as the length of highways per thousand square kilometres. These measures tend to be problematic because they do not measure how easy it is to get from one place to another, which is the ultimate goal of connectivity. For example, imagine a situation where road networks are dense on both sides of a river, but the absence of bridges makes traversing the river challenging.

Another problem associated with density-based measures is that they do not take into account demand for transport. The Gobi Desert will exhibit significantly lower road density than Greater Tokyo, but of course, it is preposterous to claim on this basis that more roads need to be built in the desert!

Thankfully, the availability of a rich library of geospatial data and algorithms allow for the computation of more intelligent measures of connectivity today. This section first introduces the basic geospatial tools and concepts used to compile the connectivity measures presented, then explains how these concepts are incorporated into a composite measure of connectivity.

Computing fastest paths

Fastest path algorithms have become a part of daily life in the 2020s. Every time someone searches for directions on their smartphone, the map application will use a fastest-path algorithm to plot the most expeditious route to the desired destination. In this study, extensive use is made of fastest path algorithms[1] to construct measures of connectivity.

To plot a fastest path, four elements are required: an origin, a destination, a set of possible paths, and a set of travel speeds associated with each path (some paths may allow faster driving than others). In this study, urban settlements are used as the basic unit of origins and destinations. We are thus measuring, for all countries and border areas, the degree of connectivity between cities, as opposed to, *inter alia*, how easy it is to get around within cities. All cities[2] with a population larger than 50,000 are covered, resulting in a total of 7,891 cities across Asia. The city centroids are used as the point of origin/destination.

For the road network, OpenStreetMaps (OSM), the most comprehensive open-source data currently available, is used. As open-source data, OSM may not be as comprehensive in its coverage as other commercially available road network layers. However, the gaps in OSM's coverage are largely confined to lower-level streets, which may be important for navigating to one's favourite local restaurant but are less so for driving to another city. For the latter, OSM has more than sufficient coverage of major roads, such as motorways, trunks, primary and secondary roads, which are the road type layers used in this study.
Driving speed assumptions (see Table 1) are assigned to each road layer to allow for differentiation between different types of road—a

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[1] The OD Matrix algorithm of the QNEAT3 Plugin in QGIS is used for fastest path computation in this study.

[2] Pesaresi, Martino; Florczyk, Aneta; Schiavina, Marcello; Melchiorri, Michele; Maffenini, Luca (2019): GHS settlement grid, updated and refined REGIO model 2014 in application to GHS-BUILT R2018A and GHS-POP R2019A, multitemporal (1975-1990-2000-2015), R2019A. European Commission, Joint Research Centre

country with more highways will tend to have better connectivity. This presents a methodological challenge as there can be a lot of variation in speed limits, congestion and road quality between countries. However, as the purpose of this study is to assess physical transport networks, the authors chose to adopt uniform speed assumptions across all countries to emphasise variation in the quality and geometry of the road network itself.

Table 1: Speed assumptions by road type

OSM road class	Speed
Motorway	100km/h
Trunk	75km/h
Primary/secondary	65km/h

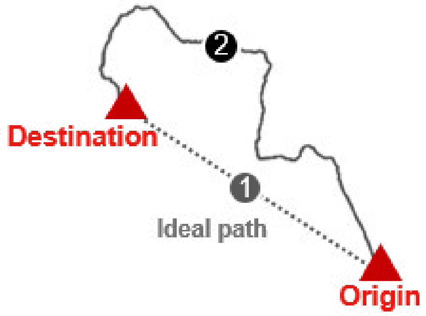
Data source: Approximations based on averages taken from OSM Wiki.

It is true that safe maximum driving speeds (and thus connectivity) depend, to some extent, on the quality of the road surface. The authors acknowledge that such nuances are not reflected in the connectivity measures presented. Accounting for such differences would make for a vastly more complex exercise. For the fastest path analyses, all highways are assumed to offer the same driving speeds.

From fastest paths to network efficiency

The first step in compiling the country- and border-level measure of road connectivity is to compute fastest path travel times for all possible pairs of cities. This is done at two levels: national level (all city pairs within a country) and border level, (for all cross-border city pairs for cities within 200km of a border).

Figure 1: Illustration of fastest and ideal paths



Fastest travel times alone are insufficient to assess connectivity, as this would be unfair to large countries. In Russia, for example, it takes 29 hours to drive between a random pair of cities, compared with 17 minutes for Kuwait. Using “ideal travel time” as a lower bound to normalize the data makes for fairer comparison across countries.

Ideal travel time is constructed simply by calculating the time it would take to drive at maximum speed (100km/h) in a straight line between two cities. The ratio of the fastest path travel time to its ideal counterpart forms the basis of the connectivity measure. If ideal time requires a 30-minute drive, compared with one hour in actuality, then the ratio is 0.5. This ratio is computed for all city pairs within a country or a border area.

Before summarising the ratios into a national indicator, a final step is necessary. Not all city pairs are equal in terms of travel demand. Travel demand tends to be highest between large cities, and so the ratios should be weighted according to the population of the city pairs. This ensures that the final indicator, called the Network Efficiency Ratio (NER)[3], is appropriately weighted to emphasise the more important connections. In formal terms, the NER for country z is expressed as:

$$NE_z = \frac{\sum_{ij} \frac{ATT_{ij}}{IDT_{ij}} \cdot POP_i \cdot POP_j}{\sum_{ij} POP_i \cdot POP_j}$$

$$NER_z = \frac{1}{NE_z}$$

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[3] Gutiérrez, J., Monzón, A., & Piñero, J. M., 1998. “Accessibility, Network Efficiency, and Transport Infrastructure Planning.” Environment and Planning A, 30(8), 1337–1350. doi:10.1068/a301337, cited by Christodoulou et al. (2019), “Road Accessibility In Border Regions.” European Commission, Regional and Urban Policy, https://ec.europa.eu/regional_policy/sources/docgener/work/2019_01_road_access.pdf.

where, for city pairs *i* and *j*, ATT is the actual travel time for the fastest path, IDT represents ideal travel time, and POP stands for population.

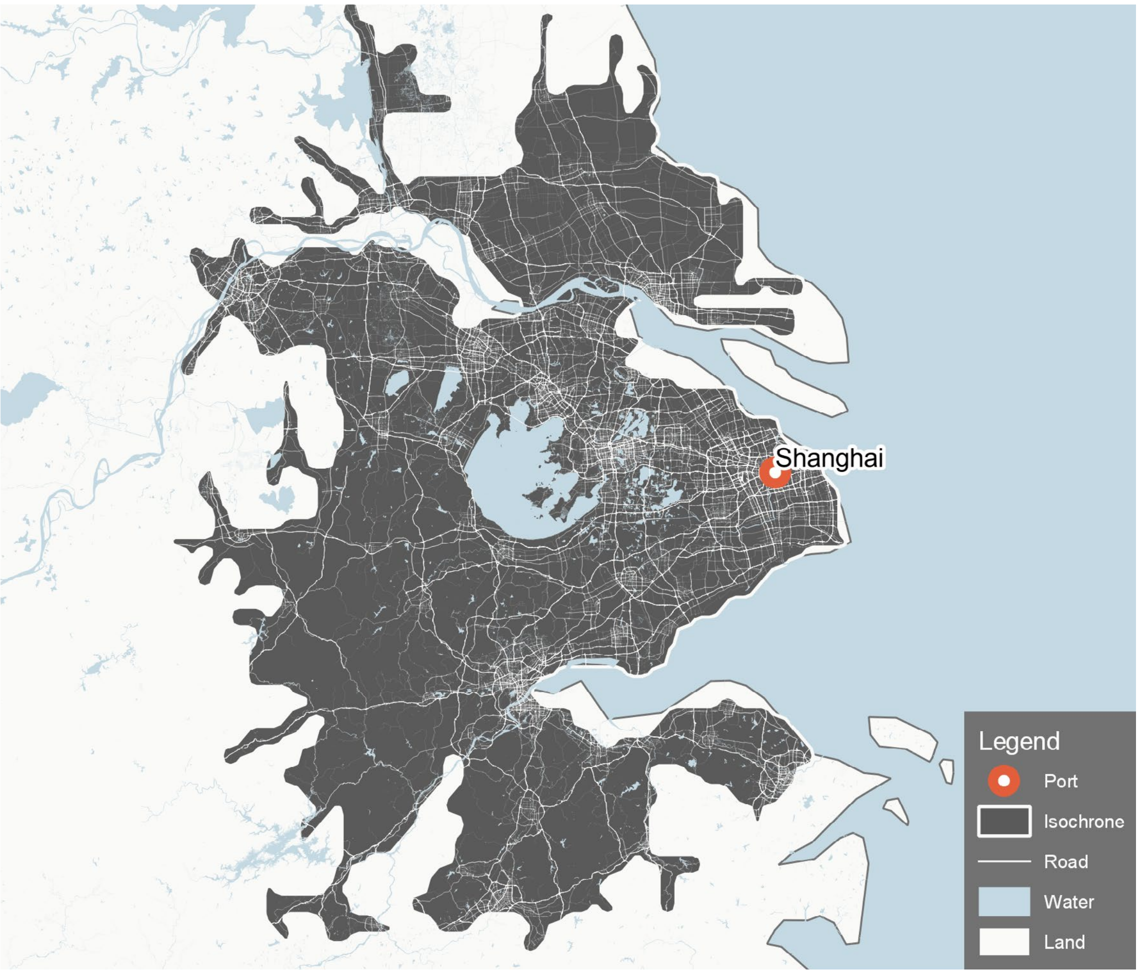
The interpretation of the NER is straightforward. If a country were to attain the maximum value of 1, its road network would have to consist of direct highway connections between all cities. Naturally, such a road network is unattainable and even undesirable—it would be absurd for every village, town and city to have a straight highway to every other one as the entire country would likely be covered by roads. An NER of 0.5 would mean that it would take twice as long for a randomly selected person in the country to travel to another randomly selected city compared with the ideal case.

Isochrones

While a fastest path represents the quickest route between two points, it does not help in answering questions concerning the area of coverage. The owner of a shopping mall, for example, may want to know how many people live within a 20-minute drive of the mall. Likewise, an infrastructure planner may ask how many factories are located within a 1-hour drive of a new port.

Answering these questions requires computing an isochrone (see Figure 2). Isochrones can be based on any time limit. A two-day isochrones, for instance, would be extremely large and cover most countries. A one-minute isochrone may cover a few

Figure 2: 4-hour isochrone from Shanghai port



Data source: Isochrone: HERE Routing API, Road and water: OSM, Land polygon: Natural Earth.

blocks. The road network is also an important factor in determining the extent of an isochrone. An area with extensive highways will likely have much larger isochrones than one with few roads.

For this study, isochrones are computed using HERE Technologies' Routing API. As with the fastest path analysis, a "no traffic" assumption is used to create as controlled an environment as possible and isolate variability to the characteristics of the physical road network.

Using isochrones to measure connectivity

Following the spirit of using actual versus ideal travel times in constructing the Network Efficiency Ratio, it is also possible to benchmark isochrones against an "ideal". The ideal isochrone is essentially the two-dimensional counterpart of the ideal path—a circle whose radius is determined by a combination of speed and travel time. The ideal counterpart of a 1-hour isochrone where the maximum speed is 100km/h is thus a circle with a 100km radius, often referred to as an "as-the-crow-flies" circle.

The ratio of the area of the isochrone to the circle then becomes a natural measure of the connectivity associated with a given point, such as a port. The measure can be given even more meaning by including other data of interest. One study assesses transport performance in Europe by measuring the ratio of the population within the isochrone to that within the circle. Since this study focuses on connectivity in the context of trade, factories and ports are our main variables of interest.

Table 2: Data sources for port connectivity analysis

Ports	**Population**[4]	**Factory**
UNCTAD regularly publishes a Port liner shipping connectivity index (PLSCI)[5] to evaluate the connectivity of worldwide container ports in the global liner shipping network. Geolocation information on 495 ports in Asia collated in the PLSCI from a range of open-source port location databases[6,7,8,9] form the scope of the analysis.	The Global Human Settlement Layer population grid data (2019) is an open-source population raster layer that provides population distribution estimates in 2015 at high geographical resolution. This layer is the basis for population coverage.	For India, the HERE Map India dataset provides information on industrial zones and industrial complexes, defined as non-residential areas dedicated to industrial/storage activities. Centroids of 19,452 industrial complex polygons are used for factory counts in isochrones. Factory data for the rest of Asia is assembled from the OSM database, consisting of 338,987 centroid points from polygons under the "landuse=industrial" tag.

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[4] Schiavina, M, Freire, S, & MacManus, K (2019) "GHS population grid multitemporal (1975-1990-2000-2015), R2019A". European Commission, Joint Research Centre (JRC) [Dataset] doi:10.2905/0C6B9751-A71F-4062-830B-43C9F432370F PID: http://data.europa.eu/89h/0c6b9751-a71f-4062-830b-43c9f432370f;

[5] Port liner shipping connectivity index (PLSCI), UNCTAD, https://unctadstat.unctad.org/wds/TableViewer/summary.aspx

[6] International Ports, World Bank, https://datacatalog.worldbank.org/dataset/global-international-ports

[7] World Port Index, National Geospatial-Intelligence Agency, https://data.humdata.org/dataset/world-port-index

[8] Global Ports, World Food Programme, https://geonode.wfp.org/layers/esri_gn:geonode:wld_trs_ports_wfp

[9] World Port Source, www.worldportsource.com

[10] Dijkstra, L, Poelman, H & Ackermans, L (2019), "Road Transport Performance In Europe, Introducing a new accessibility framework", European Commission, Regional and Urban Policy, https://ec.europa.eu/regional_policy/sources/docgener/work/2019_02_road_transport.pdf

ROAD CONNECTIVITY IN ASIA

Roads are arguably the most fundamental component of transport networks. Without an extensive supporting road network, air, sea and rail ports would all be rendered inaccessible. Following the methodology outlined in the previous section, this section presents the findings of the road connectivity analysis across Asia, first at a national level and then for cross-border connections.

It should be noted that the basic unit of analysis for connectivity in this section is an urban settlement, defined as a contiguously-built urban area with a minimum population of 50,000. Villages are excluded from the analysis, and analysed road networks exclude tertiary roads and streets. Intra-city connectivity is also excluded from the analysis. The measures compiled thus place emphasis squarely on inter-city road networks.

Domestic road connectivity analysis

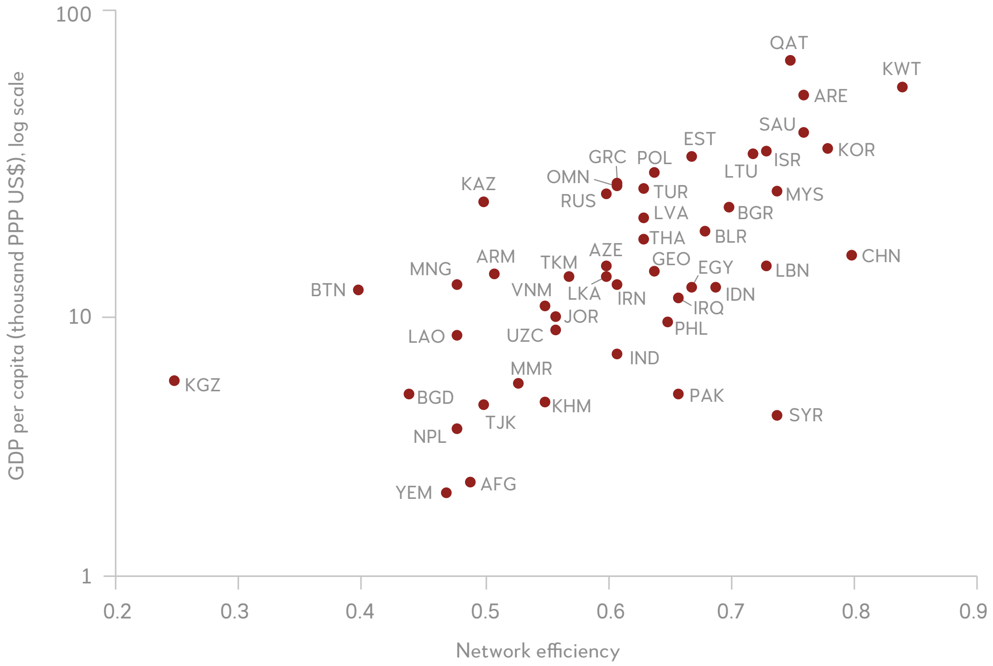
The analysis shows a high degree of variation in road connectivity, measured according to the Network Efficiency Ratio (NER), across Asia (see Table 3). The highest-scoring

Table 3: Network efficiency ratios for AIIB regional member countries
(Germany and the Netherlands added for comparison)

	Expected travel time (hours)	Ideal travel time (hours)	Network Efficiency Ratio
China	14.32	11.54	0.80
Germany	3.99	3.16	0.78
South Korea	2.69	2.14	0.78
Netherlands	1.11	0.87	0.76
Saudi Arabia	9.10	7.03	0.76
UAE	1.61	1.22	0.76
Qatar	0.56	0.42	0.75
Malaysia	3.17	2.35	0.74
Israel	0.98	0.72	0.73
Indonesia	4.98	3.59	0.69
Egypt	3.41	2.36	0.67
Pakistan	8.24	5.58	0.66
Philippines	2.24	1.42	0.65
Georgia	3.13	2.00	0.64
Thailand	6.60	4.03	0.63
Turkey	8.29	5.33	0.63
Oman	5.08	3.14	0.61
India	16.34	10.00	0.61
Iran	10.26	6.22	0.61
Azerbaijan	2.79	1.72	0.60
Russia	29.04	16.93	0.60
Sri Lanka	2.54	1.51	0.60
Jordan	1.27	0.74	0.56
Uzbekistan	6.78	3.83	0.56
Cambodia	4.17	2.36	0.55
Vietnam	12.59	6.67	0.55
Myanmar	6.94	4.00	0.53
Tajikistan	3.06	1.47	0.50
Kazakhstan	22.93	10.61	0.50
Afghanistan	7.68	3.82	0.49
Nepal	4.77	2.37	0.48
Laos	8.06	3.76	0.48
Mongolia	4.98	2.37	0.48
Bangladesh	4.07	1.88	0.44
Kyrgyz Republic	9.87	2.32	0.25

Data source: Road network: OSM, Population: Global Human Settlement Layer, Calculations: EIU.

Figure 3: Road Network Efficiency Ratios and GDP per capita in Asia



Data source: EIU, OSM.

countries in the region are world-leading, with a number of countries outscoring the most connected economies in Europe. Using the same methodology, the road networks of Germany and the Netherlands produce scores of 0.78 and 0.76, respectively.

This may come as a surprise, especially to Germans accustomed to driving on the autobahn at speeds up to 200km/h. It is worth remembering that a uniform driving speed of 100km/h is imposed for highways in the analysis to enable international comparison of physical road networks, rather than speed limits.

In general, Asia's more developed economies tend to exhibit a higher NER—the correlation coefficient between GDP per capita (PPP$) and national NERs is high at 0.57. The relationship between economic development and road connectivity is complex, with causality running in both directions. More advanced economies have more resources to invest in building high quality infrastructure. At the same time, better road networks mean firms have better access to internal markets, lower transport costs, less wastage, lower inventories and so forth, which in turn boosts productivity and GDP.

Yet, GDP per capita explains only 37% of the variation in NERs, suggesting a diverse range of factors that determine road connectivity. A Shapley value regression analysis helps to shed some light on factors that influence the NER. Variables explored include:

- Length and density of the road network
- Share of highways in road network length
- Terrain ruggedness, measured as variation in elevation across one sq km cells
- Water bodies, measured as the share of water bodies of the country's surface area
- Boundary constraints, measured as the share of straight paths between cities that intersect with a land boundary (thus preventing construction of straight roads)

Results of the regression are shown in Table 4. The Shapley values decompose the relative importance of each variable in the overall fit of the

Table 4: Shapley value regression decomposing NER determinants

Variables	coef	se	T	pval	r2	Relative importance	Relative importance (%)
Intercept	0.460	0.045	10.250	0.000	0.777		
Share of highways	0.006	0.001	4.392	0.000	0.777	0.314	40.4%
Road density	0.044	0.010	4.304	0.000	0.777	0.215	27.6%
Ruggedness	-0.0003	0.000	-4.938	0.000	0.777	0.170	21.9%
Water bodies	-0.006	0.002	-2.455	0.018	0.777	0.060	7.8%
Boundary constraints	-0.001	0.000	-1.819	0.076	0.777	0.018	2.3%

Data source: Road network: OSM, Ruggedness: Nunn, Nathan, and Diego Puga, Water bodies: OECD, Boundary constraints: Natural Earth, GHS urban centre layer, Calculations: EIU.

Table 5: Ranking of Asian countries by network efficiency and associated factors

		Road network		Terrain and borders		
Country	**Network efficiency ratio**	**Share of highways**	**Road density**	**Rugged-ness**	**Water bodies**	**Boundary constraints**
Relative indicator importance*		40%	28%	22%	8%	2%
China	1	2	7	20	19	13
South Korea	2	4	1	22	20	16
Saudi Arabia	3	6	21	9	1	6
UAE	4	3	5	8	6	28
Qatar	5	1	3	1	9	33
Malaysia	6	5	13	12	12	14
Israel	7	7	2	19	21	20
Indonesia	8	14	20	11	16	15
Egypt	9	8	23	7	10	4
Pakistan	10	10	17	21	27	10
Philippines	11	22	9	24	18	26
Georgia	12	11	15	30	4	5
Thailand	13	23	11	14	28	29
Turkey	14	12	10	29	17	18
Oman	15	9	22	17	2	7
India	16	25	8	13	26	11
Iran	17	19	16	26	13	8
Azerbaijan	18	13	12	18	15	9
Russia	19	24	31	10	24	25
Sri Lanka	20	15	4	6	22	22
Jordan	21	20	18	16	3	1
Uzbekistan	22	27	27	4	30	30
Cambodia	23	27	26	5	32	12
Vietnam	24	17	6	25	31	32
Myanmar	25	16	25	23	23	19
Tajikistan	26	27	24	33	14	27
Kazakhstan	27	18	32	3	29	17
Afghanistan	28	27	30	27	7	3
Nepal	29	27	19	32	5	21
Laos	30	21	28	28	11	31
Mongolia	31	26	33	15	8	1
Bangladesh	32	27	14	2	33	23
Kyrgyzstan	33	27	29	31	25	24

Data source: Road network: OSM, Ruggedness: Nunn, Nathan, and Diego Puga, Water bodies: OECD, Boundary constraints: Natural Earth, GHS urban centre layer, Calculations: EIU.

model (R squared). This is done by taking the average R-squared contribution of the variable in all possible variable combination specifications (shown in the final column). The coefficient estimates and associated diagnostic statistics shown are for the all-variable regression specification. The model's high R-squared indicates that a substantial amount of the variation in the NER is captured by the five variables.

Highways stand out as the dominating factor driving variation in the NER, given the speed improvements enabled by traffic-light-free, multi-lane carriageways. It is notable that increasing the share of highways in the road network has more impact on the NER than increasing the length of the network. Generally, countries gain more connectivity from upgrading roads than building new ones, though there are exceptions, particularly when important links such as bridges are missing.

Terrain clearly also matters. In particular, ruggedness explains 22% of the (explained) variation in the NER. Rugged terrain substantially increases the costs of road development and maintenance and severely limits routing options, leading to inefficient networks. Nepal, Kyrgyzstan and Tajikistan are among the world's most mountainous countries and hence show low connectivity scores.

Table 5 shows the ranking of countries for the variables included in the regression, which helps to understand the relative performance of countries. China performs well largely due to its extensive highway network, second only to Qatar (which also happens to be the flattest country studied).

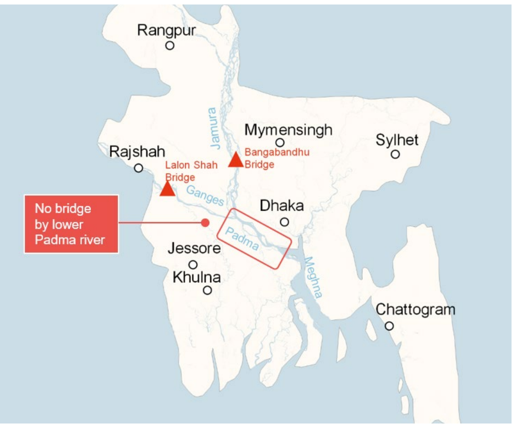
Interestingly, boundary constraints are a statistically significant variable in the regression but do not contribute much to NER variation. Countries where the spatial pattern of urban settlements does not permit for direct, straight roads suffer a mild penalty in the NER. For instance, a straight line between Hanoi and Ho Chi Minh City, Vietnam's two largest metropolitan areas, would have to cross Laos. A south-bound road from Bangkok would need to curve to fit the narrow contours of peninsular southern Thailand.

Finally, it is noteworthy that there are no apparent (dis)economies of scale in the NER. Larger or smaller road networks, measured either by total road network length or number of cities, play an unimportant role in driving variation. It can thus be said that the NER is a "size agnostic" measure.

Case study – Bangladesh's bridge problem

Bangladesh stands out as a country with particularly challenging natural conditions for road connectivity. The densely-populated country's land area (see Figure 4) is split into three sections by the mighty Padma (Ganges) and Jamuna (Brahmaputra), the world's 3rd and 9th largest rivers in terms of discharge. At the time of writing, only two bridges spanning these rivers were in operation: Lalon Shah and Jamuna. No bridges are currently in operation on the lower stretch of the two rivers after they join. However, the Padma Bridge, under construction, aims to address this issue. Naturally, the shortage of bridges creates a large drag on Bangladesh's NER.

Figure 4: Bangladesh's lack of downstream bridges



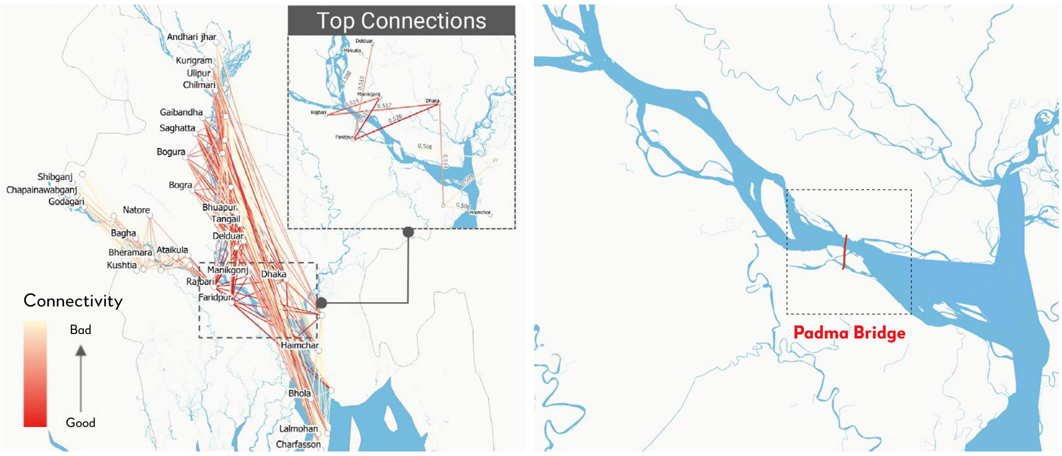
Data source: Country polygon: Natural Earth, Rivers: OSM.

Where would a new bridge create the largest boost to Bangladesh's NER? To answer this question, 263 hypothetical bridges are generated across pairs of all 47 riverside major urban centres. The impact of each of these hypothetical bridges on Bangladesh's NER is computed to identify the top efficiency-improving new links.

Unsurprisingly, new connections on the lower stretch of the Padma yield the most significant improvement to the country's NER. While it is currently possible to cross the lower Padma by ferry, the boat trip adds up to 3 hours to the journey. By road, the river crossing would be achievable in under 15 minutes, making it clear why the upcoming Padma Bridge is sorely needed. When in operation, the new bridge will shorten the travel time of 8,500 out of 37,000 inter-city paths in Bangladesh and increase the country's NER from 0.44 to 0.50, boosting Bangladesh by five places in the NER rankings.

This case study illustrates how singular improvements in a country's road network can bring large improvements in connectivity on a nationally significant scale, with evident implications for economic efficiency.

Figure 5: Simulating new connections in Bangladesh



Data source: Country polygon: Natural Earth, Rivers: OSM, Cities: Global Human Settlements Layer, Calculations: EIU.

Cross-border road connectivity analysis

The analysis points to significant room for improvement in cross-border connectivity in the region. Cross-border NERs are notably lower than the domestic NERs presented in the previous section. The average cross-border NER is 0.51, compared with 0.61 for the domestic measure. Moreover, unlike domestic connectivity where the best-connected countries in Asia outperformed their advanced economy peers, the highest-scoring borders in Asia fall short of those in Europe. The NER for the Netherlands-Germany border is 0.79, compared with 0.75 for the Jordan-Syria border (see Table 6).

Why does Asia underperform on cross-border connectivity? A quick examination of the features of the continent's physical road network is revealing. While most countries in the region are in the early-to-mid stages of building national highway networks (some, such as South Korea, China and Japan are already quite advanced), complete cross-border highways links are non-existent except for in the cases of Malaysia-Singapore and China-Vietnam (near complete). There are also countries that lack cross-border road connections altogether. There are no mapped roads between Myanmar and Bangladesh.

Similar to the domestic connectivity analysis, developed economies and those in the Middle East (thanks partly to more accommodating terrain) score relatively well in cross-border network efficiency. South and Southeast Asian countries tend to score lower.

Border road connectivity and trade

To understand the link between road connectivity and cross-border trade, NERs are plotted against bilateral total trade data from UN Comtrade. The correlation shown is partial as it is necessary first to control for the economic size of countries (larger economies tend to trade more with each other). The Y axis thus shows the residual from the regression of total bilateral trade on the product of country pair GDP.

The overall correlation coefficient appears relatively weak at 0.19 due to a number of outliers in the Middle East and Central Asia. Countries whose exports are predominantly energy products, such as Saudi Arabia and Qatar, may not trade much with each other even if cross-border road connections are good. But there is a much tighter relationship between a subset of countries towards the top of the chart. Interestingly, the two country pairs with the most trade are also the countries with cross-border highway links in place.

The relationship between cross-border road connectivity and trade may be direct (via overland transport) or indirect, exerting itself through other means not immediately observed. Internationally comparable statistics on global trade by mode of transport remain hard to find, though it is clear that shipping via sea remains the preferred mode of transport for international trade. In the European Union (EU), seaborne transport accounted for 47% and 70% of extra-EU trade, in value and volume terms respectively, in 2018, according to the European Commission. The same figures for road transport are 20% and 3%.

The economics of transport change significantly, however, as distances get shorter and border procedures are simplified. Overland transport offers more flexibility and shorter delivery times than seaborne shipping, which may outweigh the higher costs. For intra-EU freight that requires no customs clearance, road transport accounted for 51% of freight transport in kilometre tonnes in 2018. Better road connectivity can thus reduce transport time and costs and be a powerful catalyst for trade, especially when supported by streamlined border processes.

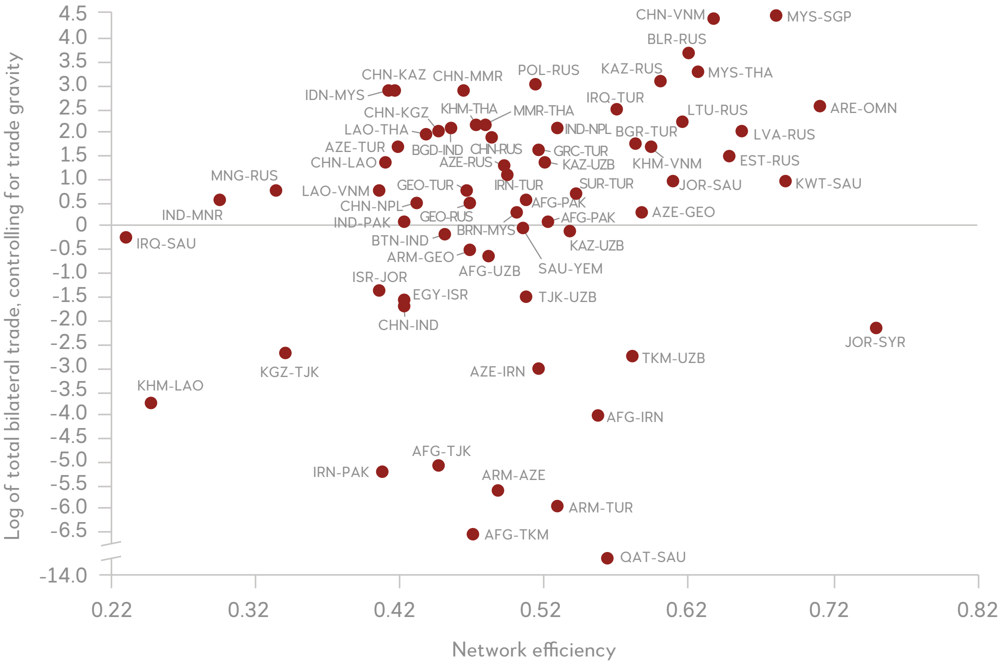
The extent to which cross-border trade in Asia takes place via overland transport is not entirely clear. Given the presence of border customs processes and lower levels of cross-border road connectivity, trucking should be a less popular option in the region compared with the EU. The correlation shown in Figure 6 is striking.

Table 6: Cross-border Network Efficiency Ratios in Asia

	Expected travel time (hours)	Ideal travel time (hours)	Network Efficiency Ratio
DEU-NLD	2.86	2.28	0.79
JOR-SYR	2.12	1.60	0.75
ISR-LBN	2.77	2.03	0.73
ARE-OMN	2.74	1.96	0.71
KWT-SAU	3.18	2.19	0.69
MYS-SGP	1.08	0.78	0.68
LVA-RUS	3.74	2.46	0.66
EST-RUS	4.72	3.07	0.65
CHN-VNM	5.65	3.66	0.64
MYS-THA	3.88	2.47	0.63
BLR-RUS	4.84	3.04	0.62
LTU-RUS	3.81	2.45	0.62
JOR-SAU	2.62	1.60	0.61
KAZ-RUS	19.93	12.00	0.60
KHM-VNM	4.30	2.48	0.60
AZE-GEO	3.75	2.21	0.59
BGR-TUR	4.93	3.05	0.59
TKM-UZB	7.17	4.42	0.58
IRQ-TUR	2.91	1.72	0.57
QAT-SAU	3.32	1.87	0.56
AFG-IRN	6.72	3.71	0.56
SYR-TUR	4.96	2.85	0.54
KGZ-UZB	3.90	2.15	0.54
ARM-TUR	3.24	1.72	0.53
IND-NPL	6.49	3.56	0.53
KAZ-KGZ	5.56	2.86	0.52
KAZ-UZB	6.46	3.04	0.52
AZE-IRN	6.97	3.68	0.52
GRC-TUR	4.65	2.62	0.52
POL-RUS	3.35	1.77	0.51
IRN-IRQ	8.25	4.38	0.51
TJK-UZB	5.32	2.71	0.51
AFG-PAK	6.83	3.53	0.51
SAU-YEM	5.76	3.01	0.51
BRN-MYS	3.51	1.77	0.50
IRN-TUR	5.71	2.85	0.50
AZE-RUS	6.96	3.60	0.49
ARM-AZE	4.90	2.40	0.49
CHN-RUS	10.24	5.20	0.48
AFG-UZB	5.76	2.82	0.48
MMR-THA	11.13	5.73	0.48
KHM-THA	5.05	2.52	0.48
AFG-TKM	5.77	2.51	0.47
IRN-TKM	6.73	3.31	0.47
GEO-RUS	7.10	3.46	0.47
ARM-GEO	4.06	1.91	0.47
GEO-TUR	6.50	3.19	0.47
CHN-MMR	7.61	3.54	0.47
BGD-IND	6.90	3.21	0.46
BTN-IND	4.41	2.00	0.45
AFG-TJK	5.52	2.54	0.45
CHN-KGZ	9.19	4.36	0.45
LAO-THA	7.85	3.37	0.44
CHN-NPL	9.47	4.19	0.43
CHN-IND	14.81	6.49	0.42
EGY-ISR	3.52	1.52	0.42
IND-PAK	13.00	6.19	0.42
AZE-TUR	4.50	1.90	0.42
CHN-KAZ	10.03	4.22	0.42
IDN-MYS	7.80	3.01	0.41
CHN-LAO	9.46	3.88	0.41
IRN-PAK	9.47	3.89	0.41
LAO-VNM	12.17	5.19	0.41
ISR-JOR	2.75	1.14	0.41
KGZ-TJK	10.17	3.78	0.34
MNG-RUS	12.03	4.09	0.34
IND-MMR	14.33	4.40	0.30
KHM-LAO	7.44	1.85	0.25
IRQ-SAU	14.64	4.34	0.23
BGD-MMR	-	-	-

Data source: Road network: OSM, Population: Global Human Settlement Layer, Calculations: EIU.

Figure 6: Bilateral trade and network efficiency in Asia



Data source: Network efficiency and GDP: EIU, Trade: UN Comtrade (residual from regression of bilateral trade on the product of GDP of country pairs, Calculations: EIU.

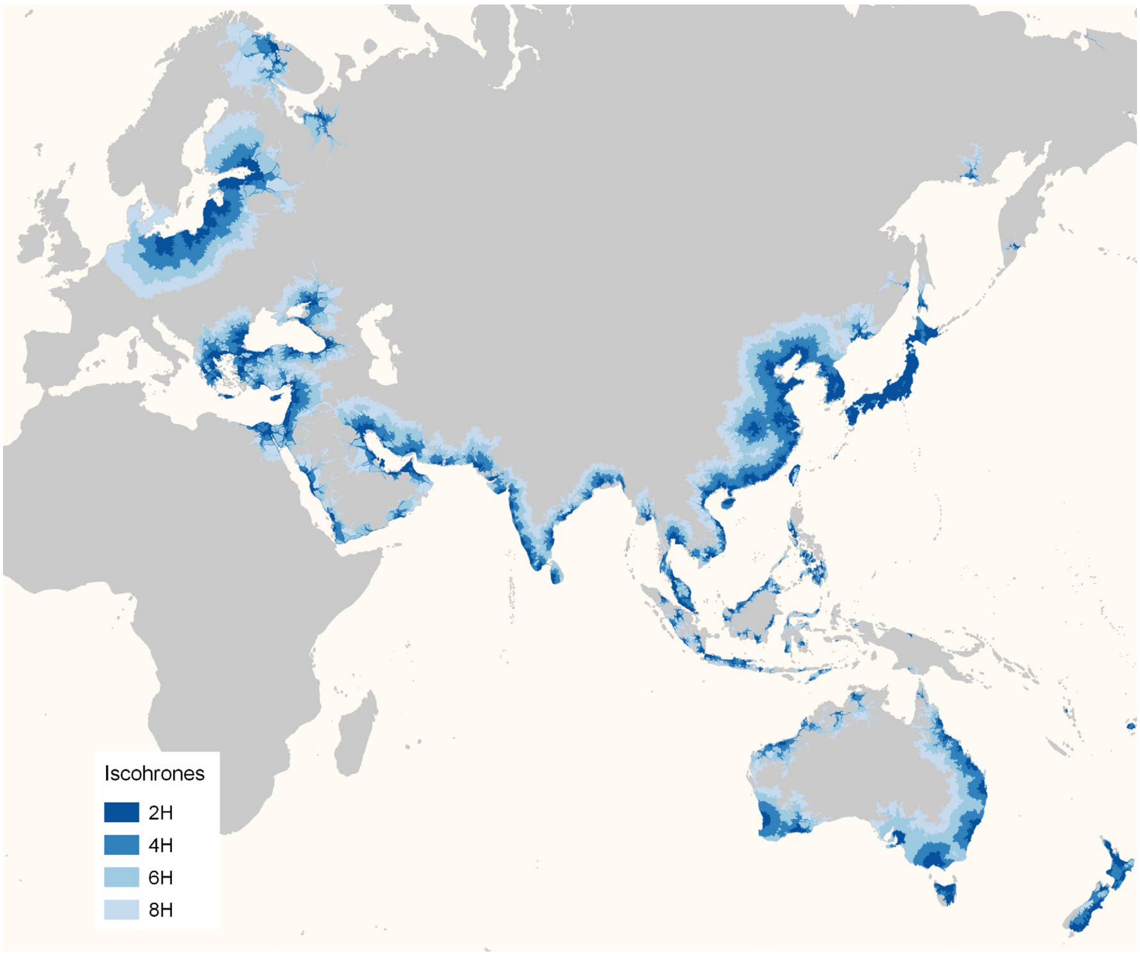
Overland transport may have a larger role to play than previously expected. Another plausible explanation is that countries with better economic ties are more proactive in promoting bilateral trade, including investing in cross-border infrastructure links while simultaneously lowering other barriers to trade. Better road connectivity can also lead to greater mobility for people, which can also enhance trade.

Clearly, the relationship between road connectivity and trade is multi-faceted. Building more cross-border highways alone may not guarantee more trade and prosperity. But it is part of a larger package that countries pursuing greater participation in global value chains should consider.

PORT CONNECTIVITY IN ASIA

With maritime trade accounting for the bulk of global merchandise trade, seaports are the gateways of global value chain participation for most firms. Export/import firms tend to be located close to a seaport to minimise transport costs and time. But "close" need not refer to physical distance. Firms can enjoy significantly lower travel times to a port that is well-connected by a highway network compared with one that lacks proper road connectivity, even if they are further away.

Figure 7: Isochrones of liner ports in Asia



Data source: Isochrones: HERE Routing API, Land polygons: Natural Earth.
Note: All isochrones shown in this section of the report have been generated from the same data source.

Industry access to ports

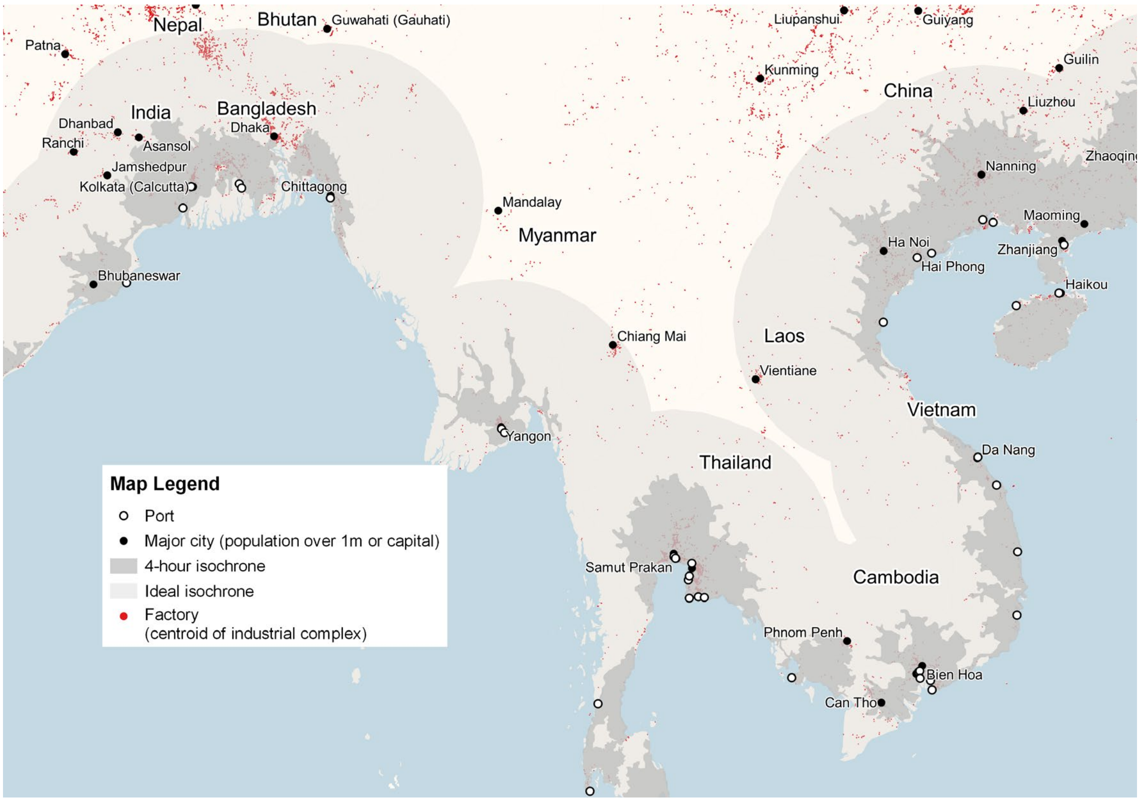
To understand the access that firms across Asia have to seaports, the first step is to generate isochrones (see methodology section for detail) for Asia's ports. This is done at two-hour intervals up to 8 hours, which represents a full day's drive time.[11] A total of 324 liner shipping ports in AIIB regional member countries and other countries of interest are included, covering well over 90% of container traffic in the region. Figure 7 shows the isochrones for these ports across the region.

The isochrones effectively capture the extent of road connectivity in the vicinity of ports. In general, the larger the isochrone, the more extensive the road network will be. However, two-dimensional projections of the world map are often poor representations of reality. Pressing the globe onto a flat surface causes distortions—the same surface areas and lengths closer to the poles will appear larger than those on the equator. For instance, in reality, Russia, occupies roughly half the surface area that Africa does, though it appears larger.

Even despite the distortions, the benefit of an advanced highway network is visible from the map. China's port isochrones are visibly larger than in other countries at similar latitudes. China also benefits from freshwater shipping on the Yangtze, the only river in Asia to have a liner shipping port, located in the city of Wuhan.

Having large isochrones, however, does not automatically lead to high port accessibility for firms. To measure the latter, it is first necessary to account for the location of factories and then to establish an upper bound for the maximum achievable degree of connectivity. The latter is achieved by means of an "ideal isochrone" (see methodology section). A 4-hour isochrone is used

Figure 8: 4-hour and ideal isochrones for ports in Southeast Asia



Data source: Isochrone: HERE Routing API, Land polygons: Natural Earth.

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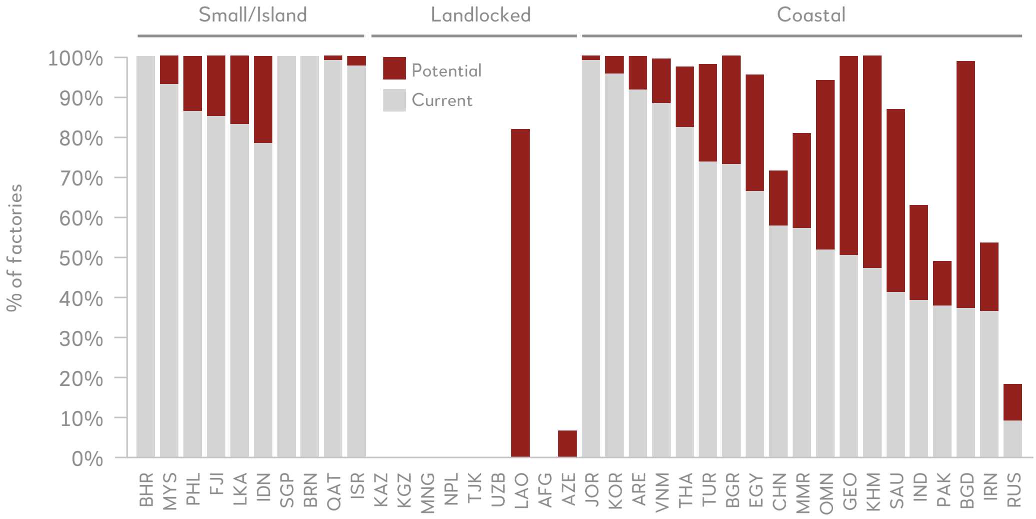
[11] To ensure international comparability, the isochrones are generated under "no traffic" assumptions.

Figure 9: Current and Potential Port-Factory Connectivity Scores by Country



Data source: Isochrone: HERE Routing API, Factory count: OSM, Calculations: EIU.

as the main benchmark in this section (as shown in the next section, 4 hours correlates well with exports). The ideal isochrone is thus 400km in radius, given a maximum driving speed of 100km/h.

Next, location data covering 338,987 industrial complexes across Asia is used to measure factory locations. Comparing the number of factories located within the 4-hour isochrone to the number of factories within the ideal isochrone by means of a simple ratio then provides a Port-Factory Connectivity Score (PFCS). The intuition is straightforward—a score of 1 means all factories within 400km can be reached within 4 hours, while a score of 0.5 suggests only half can.

Figure 9 illustrates the PFCS for countries in Asia. Small or island countries are grouped separately given that their natural geography will tend to boost the PFCS. Similarly among the coastal countries, many perform well as a result of geographic conditions—a relatively small land area combined with extensive coastlines. This is the case for nearly all countries with a PFCS higher than 0.85.

Of the larger coastal countries, Thailand scores the highest, thanks largely to a combination of highway connectivity and the bulk of Thailand's manufacturing industry being located in the Bangkok-Laem Chabang area. China, with the densest highway network in continental Asia, also performs well. Of the coastal countries, Bangladesh has the least-connected port areas, partly owing to challenging river delta terrain that complicates road-building. Landlocked countries fall outside of any 4-hour port isochrone and hence score zero.

Turning to potential improvements, the countries on the right of the chart have the greatest opportunity to increase port access to industry, in particular, Bangladesh, Cambodia and Laos. For the former two, over 50% of industrial facilities in the respective country can potentially be brought within the 4-hour port isochrone. In Bangladesh, it currently takes nearly six hours to make the 250km drive from Dhaka, the national capital around which much of the country's manufacturing firms are clustered, to Chattogram, which hosts the closest port. Likewise, Phnom Penh, the Cambodian capital, is a four-and-half hour drive from Sihanoukville, the main coastal port city.

While Laos is the country that stands to gain the most from road-to-port improvements, it faces a more complicated situation as a landlocked country. While Vientiane, the capital, lies on the Mekong, the Southeast Asian river does not accommodate liner shipping. Currently, drive times to the closest coastal ports in Vietnam and Thailand are in excess of 10 hours. With better road links, this time can potentially be cut in half. Better roads to port can bring multiple benefits, including lower inventory costs, greater reliability in deliveries and lower likelihoods of theft, spoilage and road accidents.

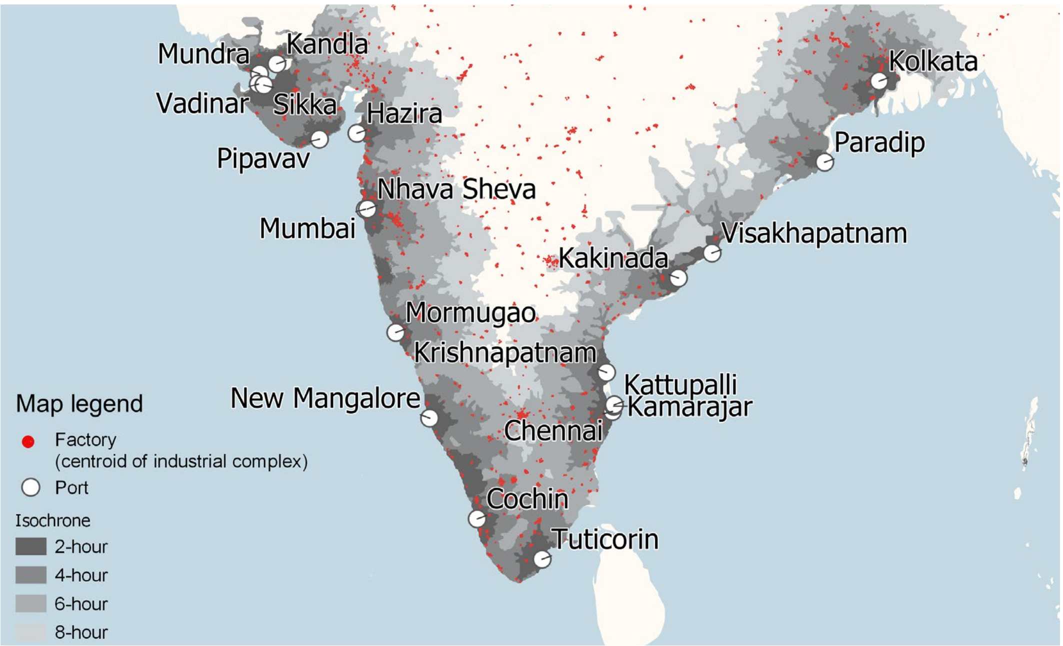
It should be noted, however, that even with better cross-border hard infrastructure, multiple soft impediments remain. While cross-border transit agreements with neighbouring countries are a common instrument for facilitating port access for landlocked countries, the implementation of such agreements has seen mixed results. Carriers in landlocked countries still face discrimination and are subject to a variety of restrictions on the "number of trips, cargo volumes, carrying capacity or numbers of permits".[12]

Case Study - Why port connectivity matters for India's exports

Building on port-level export data in India, this section illustrates how improving road connectivity to ports can potentially boost participation in global value chains. Figure 10 shows 2-hour to 8-hour isochrones for India's 20 largest ports in terms of export value in 2019. As introduced previously, an isochrone[13] is a geometric shape that maps temporal boundaries of possible travel paths.. The better connected a port is in terms of the number and quality of road connections, the larger its associated isochrones will be. Mumbai port, for instance, boasts relatively large isochrones compared with Visakhapatnam's, which is located in a more sparsely-populated region with fewer roads.

As Figure 11 shows, port-level exports are highly correlated with the number of factories[14] located within their 2- and 4- hour isochrones, which is intuitive—the more factories located near the port, the more the facility exports. The correlation falls as travel time to the port increases beyond 4 hours since factories located further from the port are less likely to be engaging in export trade. 4 hours is thus used as the benchmark for the remaining analysis in this section.

Figure 10: Isochrones of India's top 20 ports by export value in 2019



Data source: Isochrone: HERE Routing API, Factory count: OSM, Land polygon: Natural Earth, Calculations: EIU.

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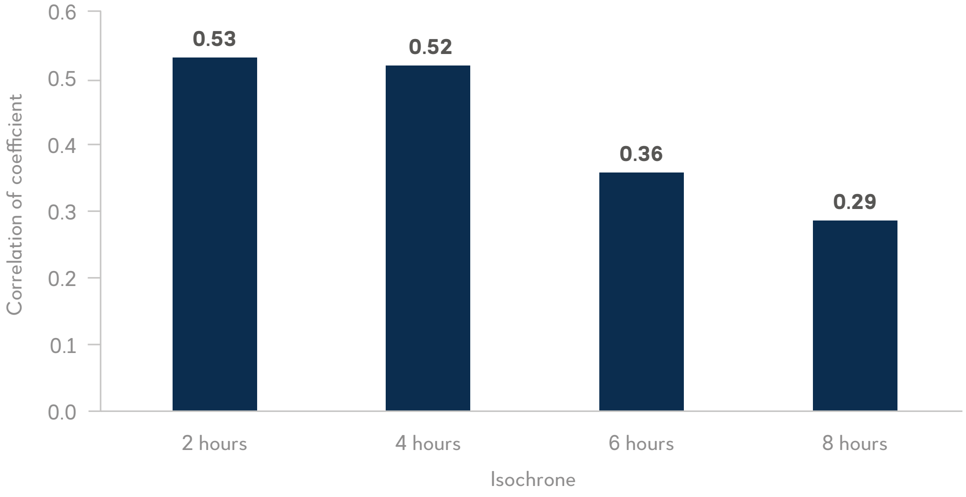
[12] Chapter 6, Review of Maritime Trade 2013, UNCTAD

[13] To ensure international comparability, the isochrones are generated under "no traffic" assumptions

[14] Defined as the number of "industrial complexes".

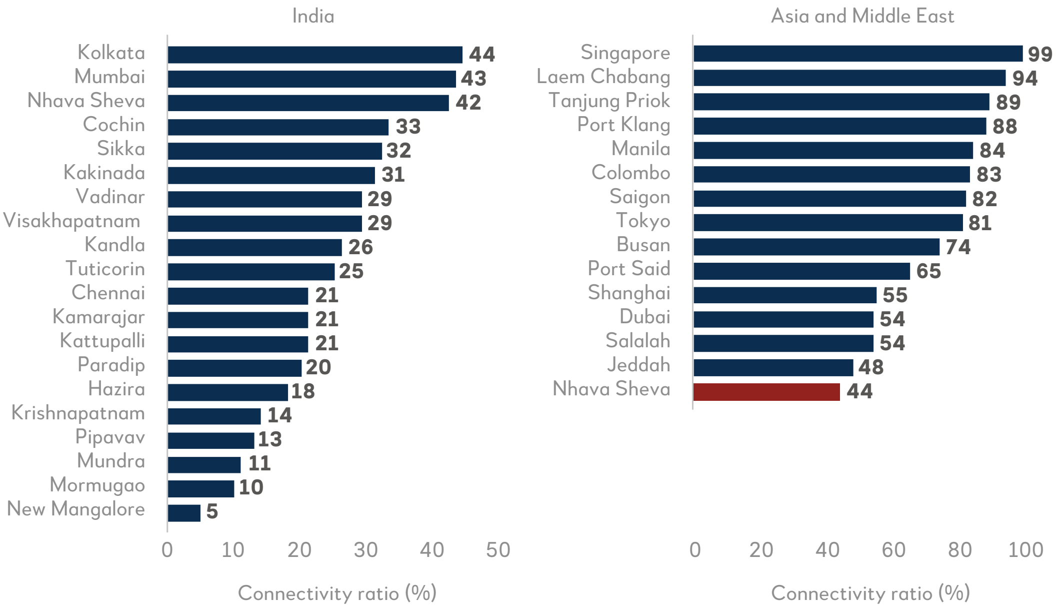
Figure 11: Correlation of port exports in 2019 and factory count by isochrone



Data source: Isochrone: HERE Routing API, Factories: HERE, Calculations: EIU.

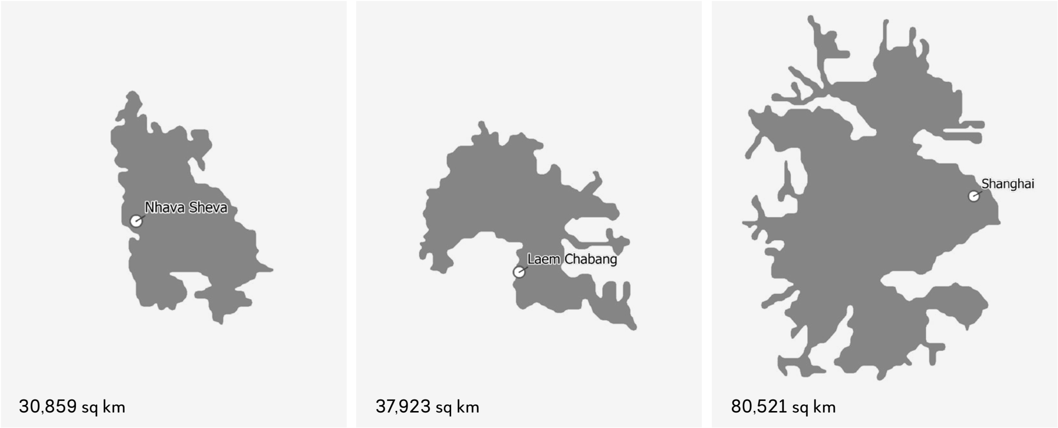
Figure 12 shows the Port-Factory Connectivity Scores for each of India's top 20 ports based on the measure described above. India's best-connected Port is Kolkata, with a ratio of 44% (in other words 44% of factories within 400km can be reached in 4 hours), Mumbai's two ports (Nhava Sheva and Mumbai Port) follow. A relatively high-quality road network around Mumbai (the city is linked by a highway to nearby Pune), coupled with clustering of industries near or in India's economic capital, account for this high performance.

Figure 12: 4-hour Port-Factory Connectivity by major port



Data source: Isochrones: HERE Routing API, Factory count in India chart: HERE, Factory data in Asia and Middle East chart: OSM, Calculations: EIU.
Note: The minor difference in the ratio for Nhava Sheva Port between the India and Asia charts is due to the use of different datasets.

Figure 13: 4-hour isochrones for select ports

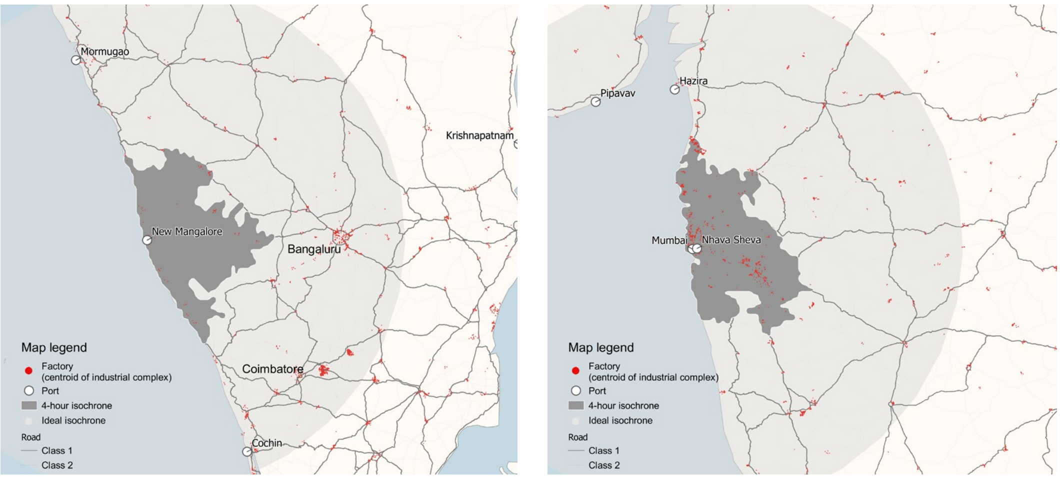


Data source: HERE

However, there is significant room for improvement. The right side chart in Figure 12 shows the connectivity ratios of Asia's "prime" ports, defined as the busiest ports in each Asian economy, selected from a list of the world's top 50 ports ranked by container traffic. Nhava Sheva, India's busiest port, significantly lags behind its peers in terms of connectivity.

To be fair, not all port isochrones are comparable. In countries less expansive than India, many ports, such as Singapore's or Malaysia's Port Klang, will have isochrones that are constrained by land area, resulting in factories being located closer to the port and therefore a higher connectivity ratio. A more suitable comparison would be the port of Shanghai or Thailand's Laem Chabang, which do not face such land constraints. For these ports, the isochrones are shown in Figure 13. The difference in the extent of the isochrones areas is stark, with Shanghai's over twice as large as the other two, illustrating the impact an extensive highway network can have. There are 144km of highway per thousand square kilometres in Shanghai's isochrone, compared with 26km and 8km for Laem Chabang and Nhava Sheva, respectively.

Figure 14: Industrial clusters and port connectivity in Mumbai and Mangalore



Data source: Isochrone: HERE Routing API, Factory count: OSM, Land polygon: Natural Earth, Calculations: EIU.

Figure 15: Manufacturing exports and port connectivity ratios

Data source: Trade data: India Ministry of Commerce and Industry, Connectivity ratios: EIU (based on HERE isochrones and factory counts).

India's least-connected of the top 20 ports, New Mangalore, only has a ratio of 5%. This is due to the fact that the bulk of industry within 400km of Mangalore is clustered around Bengaluru, which lies beyond the 4-hour isochrone (see Figure 14). Currently, it takes over 7 hours to reach Bengaluru from Mangalore by car, covering a distance of approximately 350km. With a high-speed highway link, it would be possible to nearly halve the drive time. Road trips from Paris to Brussels or from Washington DC to New York, which span a similar distance, can both be done in under 4 hours.

There may also be deeper reasons behind why New Mangalore port lacks connectivity to nearby industrial clusters. The port's exports consist largely of commodities such as petroleum products, iron ore, coffee and cashews. Bangalore's high-tech orientation may be better suited to air shipments. The connectivity measure may not capture all the historical and economic complexities of the region which should be factored into any conclusions drawn. It merely serves as a starting point for analysis. How does the road connectivity measure fare in predicting port exports? The correlation between manufacturing exports and the connectivity ratio for the top 20 ports is 0.39 (Figure 15). A notable outlier is Mundra, India's second-largest port by export value, which exports far more than its connectivity score would suggest. This is due to the port's status as the export hub for India's industrial hinterland surrounding Delhi in the North. Removing Mundra increases the correlation to 0.5.

It is important to note that correlation is not causation. Indeed, the direction of causality can run both ways. Firms may be choosing to locate in better-connected areas, or the Indian government may be prioritising road improvements in areas with more factories. Most likely, both statements are true. What is clear is that there is ample room for improvement in India's road network. Given the benefits associated with tapping into global trade networks, as outlined in Chapter 1, port connectivity may be a good place to start.

SPECIAL ECONOMIC ZONES IN ASIA

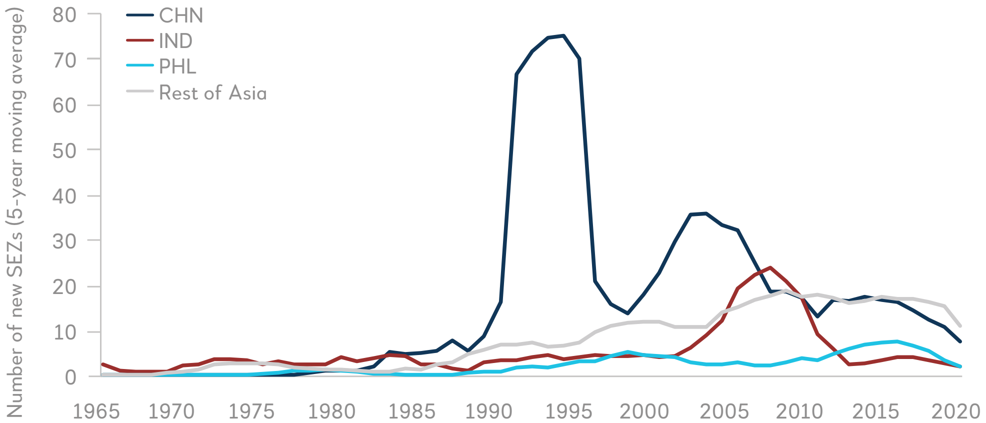
To understand the role of Special Economic Zones (SEZs) and infrastructure in advancing economic growth in Asia, the EIU assembled a spatial dataset of 2,655 SEZs. The dataset included attributes such as SEZ location (centroids), area, year of establishment, and sectoral classification.

Asia is home to three-quarters of the SEZs in the world.[15] The first SEZs in Asia were set up in the early 1960s in India, followed by the Philippines and China in the 1970s and 1980s, respectively. These were intended to serve as focal points to spur economic growth, supported by quality infrastructure and a variety of policy incentives. The 1990s and 2000s, represented the boom years for SEZ establishment (see Figure 16), led by China and India.

Currently, the countries with the largest number of SEZs in Asia are the Philippines, India, and China, the latter being the lead adopter in terms of total number of SEZs to date. Established initially in the late 1980s, China's first SEZs functioned as experimental zones for economic reform, notably for attracting foreign direct investment (FDI). The success of the zones led to wider adoption across the country, notably in 1992, the year of a major reform push to open a broad swath of coastal areas to foreign trade and investment.

Early SEZs tended to be limited to coastal countries (see Figure 17). The emphasis on attracting FDI and (export) manufacturing made port access an important factor in determining SEZ locations. More recently, SEZs have increasingly been located in inland regions and countries (see Figure 18).

Figure 16: SEZs by year of establishment



Data source: EIU

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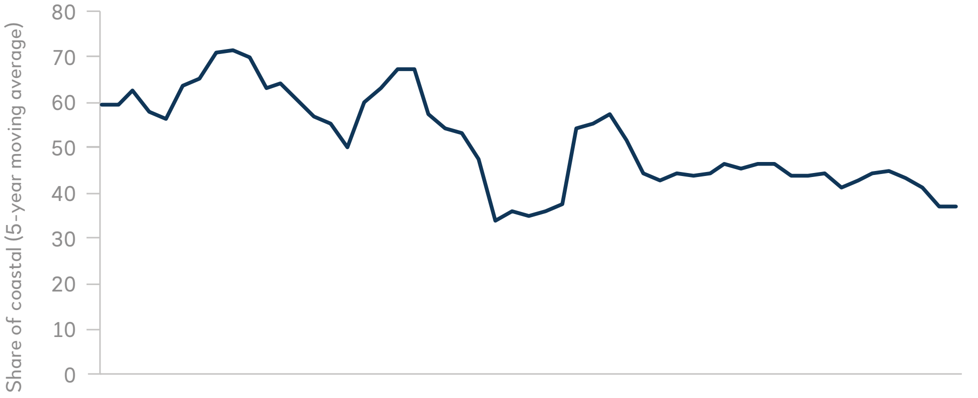
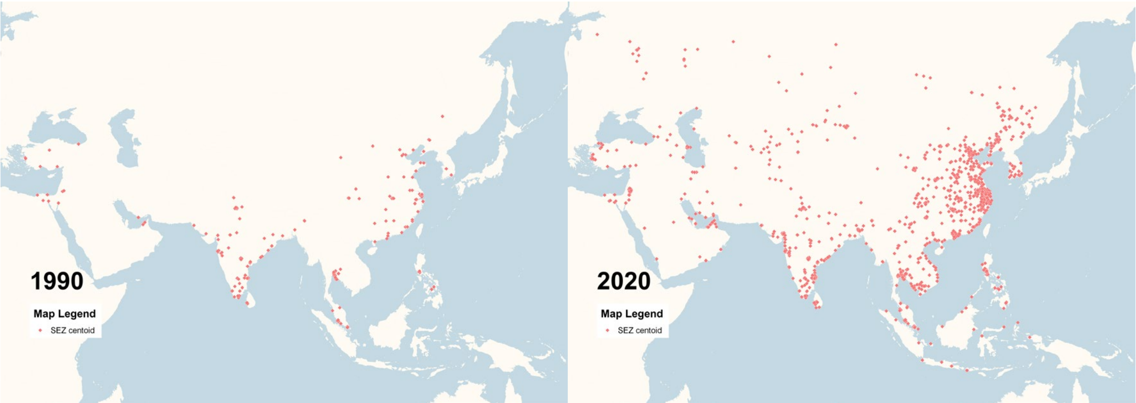
[15] Chapter 4, World Investment Report 2019, UNCTAD.

Figure 17: Share of new SEZs within 100km of coastline



Data source: EIU

Figure 18: SEZs locations in Asia



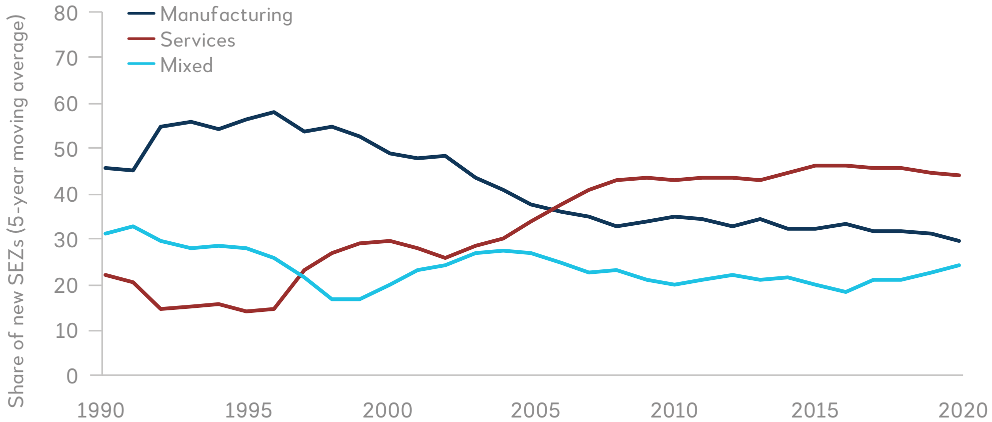
Data source: EIU, Land polygon: Natural Earth.

Two parallel trends have accompanied and perhaps even supported this shift. The first is the increasing services as a sector (SaaS) focus of SEZ development. An emphasis on services allows for greater flexibility in location choices as proximity to ports becomes less critical. The second is the Information and Communications Technology (ICT) manufacturing boom. ICT products have accounted for the bulk of growth in global trade in the past decade. High-value-added components of ICT products, such as microchips, are often transported via air, which again decreases the relative importance of seaports.

The first trend is most prominent in countries such as India and the Philippines, where services SEZs, such as software development and call centres focused on telemarketing and customer service, have proliferated. In this context, it is noteworthy that many "micro SEZs", often housed in a single building, have emerged, primarily located in the Philippines. These micro SEZs in the Philippines exported IT solutions and continued growing in number from the late 90s up to the mid-2010s.

SEZ adoption in landlocked countries such as Kazakhstan and Uzbekistan has also increased. The trend started in Kazakhstan in the early 2000s and since then SEZs in Kazakhstan have focused on a variety of industries ranging from textiles to mining, construction and manufacturing, among others. Uzbekistan's experience with SEZs began in

Figure 19: Share of new SEZs by sector across Asia



Data source: EIU

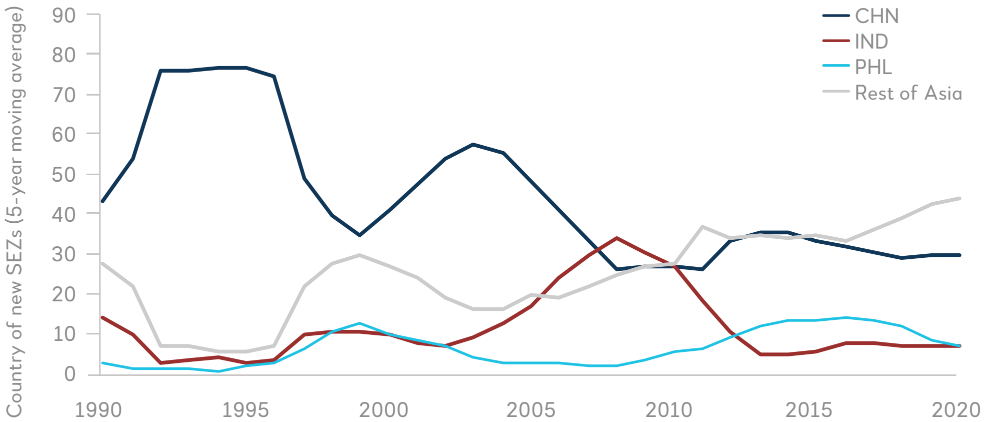
the latter half of 2000s but the country has since built a significant number of SEZs (with 63 SEZs currently operational in the country).

In China, which hosts the lion's share of Asia's SEZs, the shift inland came as part of a national strategy emerging in the mid-2000s to spread growth from wealthy coastal regions to less developed regions. Substantial investments in transport infrastructure, including highways, high-speed rail and airports were made to this end, which dovetailed well with manufacturers in coastal areas seeking lower-cost production sites. A number of SEZs can be found in inland cities such as Chongqing, Chengdu and Zhengzhou.

These inland cities were able to attract sizable investments in ICT export manufacturing by offering access to good infrastructure links and a large, flexible workforce to accommodate volatility in labour demand that is typical in manufacturing of electronics products. In particular, the high-value, low-bulk nature of ICT components enabled firms in the sector to reduce reliance on maritime transport, enabling inland cities to increase participation in global value chains.

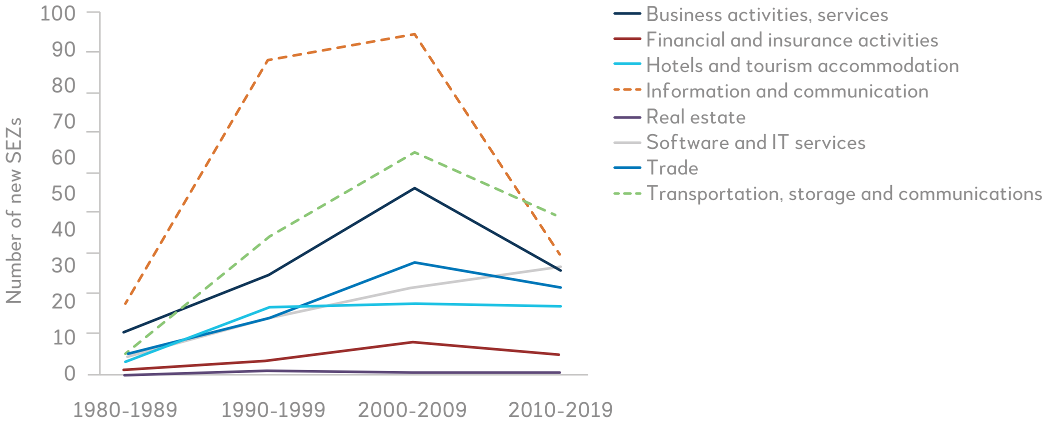
Countries across Asia witnessed a surge in services SEZs beginning in the late 1990s, with China, India and the Philippines leading the way (as seen in Figure 20). In the beginning, China focused on

Figure 20: Share of new services SEZs by country



Data source: EIU

Figure 21: Sector contributing to the service sector boom[16]



Data source: EIU

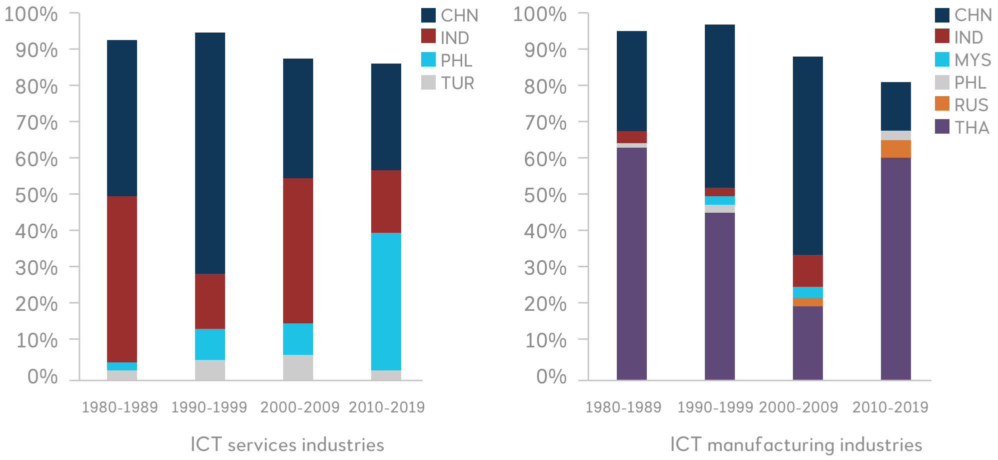
establishing a variety of economic and technical development zones along its coast and later shifted towards technology-intensive industries, setting up high-tech industrial zones in inland suburban cities to utilise growing technical capacity and R&D.

The liberalisation of the Indian economy in the 1990s enabled private sector participation and expansion of SEZs from agricultural sectors to services and manufacturing. Soon after, there was a surge in new SEZs, especially in services, as they required less land compared with manufacturing SEZs and therefore had a lower chance of being disrupted by land acquisition issues.

Similarly in the Philippines, the Special Economic Zone Act of 1995 enabled private sector investments in SEZ developments and the number of SEZs more than doubled between 1995 and 1999. As the potential of the IT industry began to be recognised elsewhere during this period, numerous IT parks and centres mushroomed in Manila.

Figure 21 illustrates the different sectors contributing to the post-1990s services SEZ boom in Asia. The ICT sector remained the highest contributor to this services boom until the late 2000s. The countries where ICT industries were particularly flourishing in Asia are highlighted in

Figure 22: Country share of new SEZs in ICT industries



Data source: EIU
Note: An SEZ may be counted more than once if it is multisectoral.

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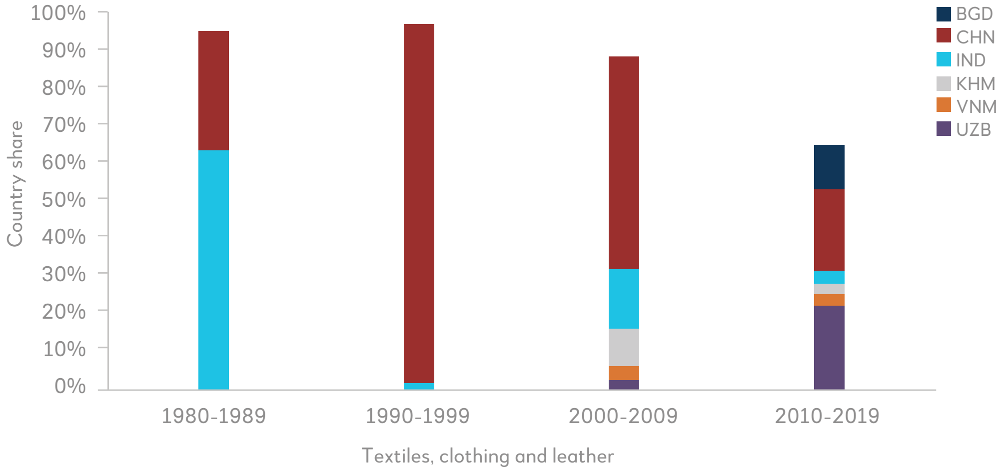
[16] An SEZ may be counted more than once if it is multisectoral.

Figure 23: Country share of textiles, clothing and leather SEZs



Data source: EIU

Figure 22. While the contributing shares of China, India and the Philippines were high both in ICT services as well as ICT manufacturing industries, countries like Thailand have significantly expanded their ICT manufacturing offerings.

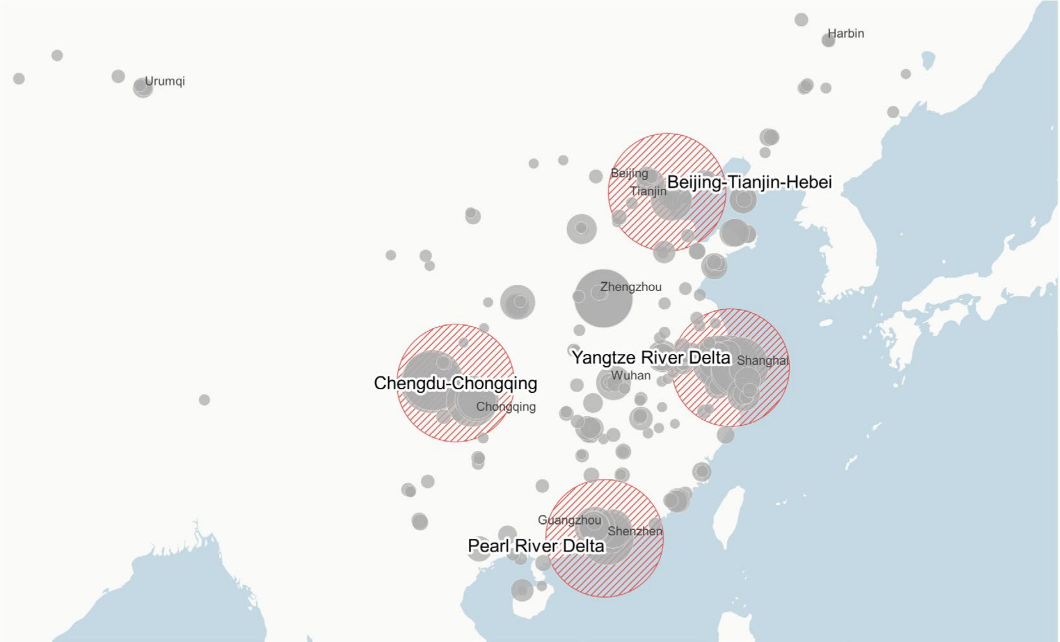
As countries like China focused on climbing the tech ladder, a number of countries in the region stepped in hoping to capture opportunities created by lower-tech investment migrating out of China. This transition is especially noticeable in the case of Bangladesh and Vietnam. Bangladesh's burgeoning textile industry has been an important manufacturing growth driver in recent years. Uzbekistan has also focused on its textile industry, which now contributes to a fifth of its GDP and employs a third of all workers involved in industrial jobs. Figure 23 illustrates the reduction in China's SEZ share of low-technology industries and the upswing in share of countries such as Bangladesh, Uzbekistan and Vietnam.

Case Study – China's SEZ export performance and transport infrastructure

With the highest SEZ count in Asia and a high degree of participation in global value chains, China provides a rich data sample that enables deeper geospatial analysis of the proximity effects of transport infrastructure on SEZ performance. The analysis draws on 2019 trade data in SEZs reported by the General Administration of Customs of China. 255 SEZs, accounting for approximately 30% of the country's international trade in 2019, are geocoded for analysis.

Figure 24: Distribution of SEZs in China

(size of bubble represents export value in 2019)



Data source: Export data: General Administration of Customs of China, Land polygon: Natural Earth.

Figure 24 shows the spatial distribution of SEZs in China, with circle sizes corresponding to 2019 export value. The largest concentrations of exports and SEZs are in the well-known manufacturing clusters of the Pearl River and Yangtze River Deltas, centred in Guangdong province and around Shanghai. A third, inland cluster can be found at the twin inland cities of Chongqing and Chengdu.

To perform a simple regression analysis, variables for the three main types of ports (air, sea, rail) are constructed using two different spatial specifications. The first measures the drive time to the nearest port, while the second counts the number of ports located within a one-hour isochrone. A fourth infrastructure variable in the form of highway density within a 100km radius is computed. Control variables include the age of the SEZ, the land area and provincial dummies.

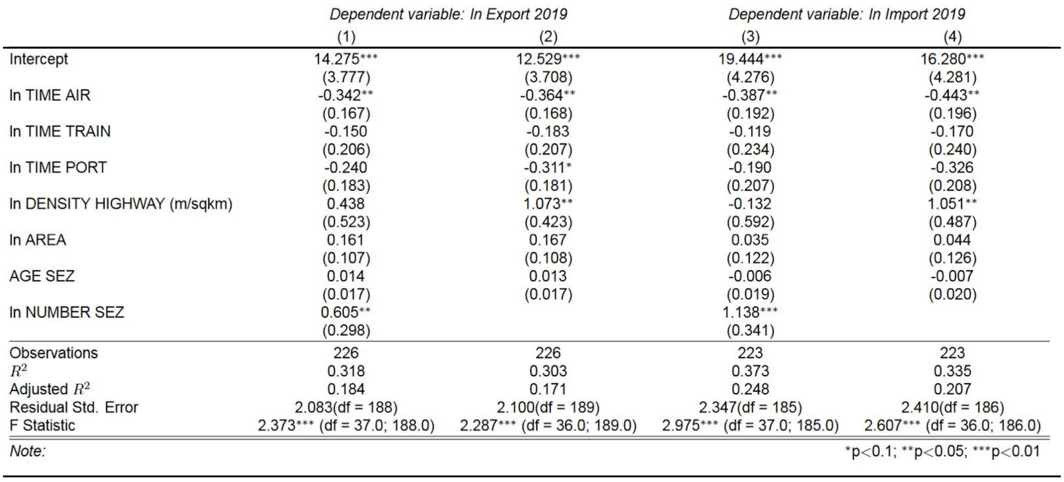
Given the strong apparent effect of regional industrial clusters, shown in Figure 24, a final variable is introduced to the model, namely, the number of other SEZs within a 100km radius. An SEZ could benefit from access to other SEZs in its vicinity, with synergies arising from a concentration of specialised labour supply, reduced logistics costs or well-aligned business policies in a region, all of which can generate a positive agglomeration effect on export performance.

Table 7 shows the regression outputs. Airports appear more robust than seaports to different model specifications in the export model. This comes as a surprise, given that maritime transport accounts for the bulk of international trade. The result can be interpreted in a number of ways. The first is simply that airports matter more for China's SEZ exports. This is not unlikely, given that ICT products comprise the bulk of China's exports and a considerable number of high-value, low-bulk products are transported via air. The second interpretation is that proximity matters more for airports than seaports. Indeed, air shipment is often preferred for just-in-time delivery in ultra-lean supply chains. Hence, when hours matter, being close to an airport may be more important than being close to a seaport.

It should be noted that when the dependent variable is switched to imports, seaports start to become significant. This may be due to differences in the product composition of imports and exports. China tends to import raw materials and intermediate goods while exporting finished goods. Raw materials tend to be bulky and hence more economical to ship via sea.

The second finding is the performance of the "number of other SEZs" variable, which, *prima facie*, points to strong agglomeration effects. A popular saying in the Pearl River Delta, arguably the world's densest manufacturing cluster, is that you can source any electronic component in the world within a one-hour drive. While that may be an exaggeration, the close proximity of technology firms—both hardware and software—and a labour force the size of Germany's in an area the size of Luxembourg may be hard to beat.

Table 7 – Regression output for drive time specification



	Dependent variable: ln Export 2019		*Dependent variable: ln Import 2019*	
	(1)	(2)	(3)	(4)
Intercept	14.275*** (3.777)	12.529*** (3.708)	19.444*** (4.276)	16.280*** (4.281)
ln TIME AIR	-0.342** (0.167)	-0.364** (0.168)	-0.387** (0.192)	-0.443** (0.196)
ln TIME TRAIN	-0.150 (0.206)	-0.183 (0.207)	-0.119 (0.234)	-0.170 (0.240)
ln TIME PORT	-0.240 (0.183)	-0.311* (0.181)	-0.190 (0.207)	-0.326 (0.208)
ln DENSITY HIGHWAY (m/sqkm)	0.438 (0.523)	1.073** (0.423)	-0.132 (0.592)	1.051** (0.487)
ln AREA	0.161 (0.107)	0.167 (0.108)	0.035 (0.122)	0.044 (0.126)
AGE SEZ	0.014 (0.017)	0.013 (0.017)	-0.006 (0.019)	-0.007 (0.020)
ln NUMBER SEZ	0.605** (0.298)		1.138*** (0.341)	
Observations	226	226	223	223
R^2	0.318	0.303	0.373	0.335
Adjusted R^2	0.184	0.171	0.248	0.207
Residual Std. Error	2.083(df = 188)	2.100(df = 189)	2.347(df = 185)	2.410(df = 186)
F Statistic	2.373*** (df = 37.0; 188.0)	2.287*** (df = 36.0; 189.0)	2.975*** (df = 37.0; 185.0)	2.607*** (df = 36.0; 186.0)
Note:				*p<0.1; **p<0.05; ***p<0.01

Data source: Calculations: EIU.

ASIAN INFRASTRUCTURE FINANCE 2021 ANNEX

MEASURING TRANSPORT CONNECTIVITY FOR TRADE IN ASIA

The Asian Infrastructure Finance 2021 report examines how Asian economies, to different extents and in different ways, have integrated global value chains (GVCs) into their growth models. It emphasizes how critical infrastructure quality and capacity are to the agility and resilience of GVCs, as examined against the backdrop of the COVID-19 pandemic, increased trade tensions, rapid technological development, environmental pressures and other factors. Using case studies and research, the AIF 2021 report illustrates how GVCs have provided opportunities for countries and companies to become internationally competitive, in part through technological advancements and efficiency improvements. It also examines how GVC engagement could reinforce existing inequalities and explores possible paths for a just and inclusive transition, recognizing countries' different starting points and capacities. The report highlights how green infrastructure, consistent with net zero transition, will become a source of competitive advantage and the key to sustaining future GVCs.

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